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ART. XIX.—*On Changes of Level in the Pacific Ocean;* by JAMES D. DANA.*

EVIDENCES of change of level in the Pacific are to be looked for in the height or condition of the coral reef formations or deposits; in the character of the igneous rocks; and in the features of the surface. The points of evidence are as follows:—

A. Evidences of elevation.

1. *Patches of coral reef, or deposits of shells and sand from the reefs, above the level where they are at present forming.*

The coral reef-rock has been shown occasionally to increase by growth of coral, to a height of four to six inches above low tide level when the tide is but three feet, and to twice this height with a tide of six feet. It may, therefore, be stated as a general fact that the limit to which coral *may* grow above ordinary low tide, is about one-sixth the height of the tide, though it seldom attains this height.

Beach accumulations of large masses seldom exceed *eight* feet above high tide, and the finer fragments and sand may raise the deposit to ten feet. But with the wind and waves combined, or on prominent points where these agents may act from opposite directions, such accumulations may be *thirty* to *forty* feet in height. These are drift deposits, finely laminated, generally with a sandy texture, and commonly without a distinguishable

* This article, cited from a chapter in the author's Expl. Exp. Geological Report, is a continuation of the previous papers on the Pacific Islands, xi, 357, xii, 25, 165, 329, xiii, 34, 185, 338, and xiv, 76.

fragment of coral or shell; and in most of these particulars they are distinct from reef-rocks. (pp. 369, 370, vol. xi.)

2. *Sedimentary deposits, or layers of rolled stones interstratified among the igneous layers.*

3. *Compactness of the igneous rocks.*—The great uncertainty of this kind of evidence has been shown in another place.

B. Evidences of Subsidence.

1. *The existence of wide and deep channels between an island and any of its coral reefs;* or in other words, *the existence of barrier reefs.*

2. *Lagoon Islands or Atolls.*

3. *Submerged atolls.*

4. *Deep bay-indentations in coasts as the terminations of valleys.*—In the remarks upon the valleys of the Pacific Islands, it has been shown that they were in general formed by the waters of the land, unaided by the sea; that the sea tends only to level off the coast, or give it an even outline. When therefore, we find the several valleys continued on beneath the sea, and their enclosing ridges standing out in long narrow points, there is reason to suspect that the island has subsided after the formation of its valleys. For such an island as Tahiti could not subside even a few scores of feet without changing the even outline into one of deep coves or bays, the ridges projecting out to sea on every side, like the spread legs of a spider. The absence of such coves, on the contrary, is evidence that any subsidence which has taken place, has been comparatively small in amount.

5. *Seashore alluvial flats or deposits.*

6. *The lava surface of a volcanic island, sloping without interruption beneath the water, instead of terminating in a shore cliff of a hundred feet or so.*

C. Probable evidence of subsidence now in progress.

1. *An atoll reef without green islets, or with but few small spots of verdure.*—The accumulation requisite to keep the reef at the surface-level, during a slow subsidence, renders it impossible for the reef to rise above the waves unless the subsidence is extremely slow.

From the above review of evidences of change of level, it appears that where there are no *barrier* reefs, and only fringing reefs, the corals afford no evidence of subsidence. But it does not follow that the existence of only fringing reefs, or of no reefs at all, is proof *against* a subsidence having taken place. For we have elsewhere shown that through volcanic action, and at times, other causes, corals may not have begun to grow till a recent period, and, therefore, we learn nothing from them as to what may previously have taken place. While, therefore, a distant barrier is evidence of change of level, we can draw no con-

clusion either one way or the other, as is done by Darwin, from the fact that the reefs are small or wholly wanting, until the possible operation of the several causes limiting their distribution has been duly considered.

The influence of volcanoes in preventing the growth of zoophytes, extends only so far as the submarine action may heat the water, and it may, therefore, be confined within a few miles of a volcanic island, or to certain parts only of its shores.

There are three epochs of changes in elevation which may be distinguished and separately considered. 1. The subsidence indicated by atolls and barrier reefs. 2. Elevations during more recent periods, and also during the same epoch of subsidence. 3. Changes of level anterior to the atoll subsidence and the growth of recent corals. On this last point, we have few facts.

1. *Subsidence indicated by atolls and barrier reefs.*

In a survey of the ocean, the eye observing its numerous atolls, sees in each, literally as well as poetically, a coral urn upon a rocky island that lies buried beneath the waves. Through the equatorial latitudes, such marks of subsidence abound, from the Eastern Paumotu to the Western Carolines, a distance of about six thousand geographical miles. In the Paumotu Archipelago there are about eighty of these atolls. Going westward, a little to the north of west, they are found to dot the ocean at irregular intervals; and at the Tarawan Group, the Carolines commence, which consist of seventy or eighty atolls.

If a line be drawn from Pitcairn's island, the southernmost of the Paumotus, by the Gambier Group, the north of the Society Group, Samoa, and the Salomon Islands to the Pelews, it will form nearly a straight boundary trending N. 70° W., running between the atolls on one side and the high islands of the Pacific on the other, the former lying to the North of the line, and the latter to the South.

Between this boundary line and the Hawaiian Islands, an area nearly two thousand miles wide and six thousand long, there are two hundred and four islands, of which *only three are high* exclusive of the eight Marquesas. These three are Ualan, Banabe (Ascension or Pounypet) and Hogoleu, all in the Caroline Archipelago. South of the same line, within three degrees of it, there is an occasional atoll; but beyond this distance, there are none excepting the few in the Friendly Group, and one or two in the Feejees.

If each coral island scattered over this wide area indicates a subsidence of an island, we may believe that the subsidence was general throughout the area. Moreover, each atoll, could we measure the thickness of the coral constituting it, would inform us nearly of the extent of the subsidence where it stands; for

they are actually so many registers placed over the ocean, marking out not only the site of a buried island, but also the depth at which it lies covered. We have not the means of applying the evidence; but there are facts at hand, which may give at least comparative results.

a. We observe, *first*, that barrier reefs are, in general, evidence of less subsidence than atoll reefs. (xiii, 186.) Consequently the great preponderance of the former just below the southern boundary line of the coral island area, and farther south the entire absence of atolls, while atolls prevail so universally north of this line, are evidence of little depression just below the line; of less farther south; and of the greatest amount, north of the line or over the coral area.

b. The subsidence producing an atoll, when continued, gradually reduces its size, until finally it becomes so small that the lagoon is obliterated; and consequently a prevalence of these small islands is presumptive evidence of the greater subsidence. We observe, in application of this principle, that the coral islands about the equator, five or ten degrees south, between the Paumotus and the Tarawan Islands, are the smallest of the ocean: several of them are without lagoons, and some not a mile in diameter. At the same time, in the Paumotus, and among the Tarawan and Marshall Islands, there are atolls twenty to fifty miles in length, and rarely one less than three miles. It is probable, therefore, that the subsidence indicated was greatest at some distance north of the boundary line, over the region of small equatorial islands, between the meridian of 150° W. and 180°.

c. When after thus reducing the size of the atoll, the subsidence continues its progress, or when it is too rapid for the growing reef, it finally sinks the coral island, which, therefore, disappears from the ocean. Now it is a remarkable fact that while the islands about the equator above alluded to indicate greater subsidence than farther south, north of these islands, that is, between them and the Hawaiian Group, there is a wide blank of ocean without an island, which is near twenty degrees in breadth. This area lies between the Hawaiian, the Fanning and the Marshall islands, and stretches off between the first and last of these groups, far to the northwest.

Is it not then a legitimate conclusion that the subsidence which was least to the south beyond the boundary line, and increased northward, was still greater or more rapid over this open area; that the subsidence which reduced the size of the islands about the equator to mere patches of reef, was farther continued, and caused the total disappearance of islands that once existed over this part of the ocean?

d. That the subsidence gradually diminished southwestwardly from some point of greatest depression situated to the northward

and eastward, is apparent from the Feejee Group alone. Its northeast portion, as the chart shows, (see vol. xiv,) consists of immense barriers, with barely a single point of rock remaining of the submerged land; while in the west and southwest there are basaltic islands of great magnitude. Again, along to the north side of the Vanikoro Group, the Salomon Islands, and New Ireland, there are coral atolls, though scarcely one to the south.

In view of this combination of evidence, we cannot doubt that the subsidence increased from the south to the northward or northeastward, and was greatest between the Samoan and Hawaiian Islands near the centre of the area destitute of islands, about longitude 170° to 175° W. and 8° to 10° N.

But we may derive some additional knowledge respecting this area of subsidence from other facts.

Hawaiian Range.—We observe that the western islands in the Hawaiian Range, beyond Bird Island, are coral islands, and all indicate some participation in this subsidence. To the eastward in the range, Kauai and Oahu have only fringing reefs, yet in some places these reefs are half a mile to three-fourths in width. They indicate a long period since they began to grow, which is borne out by the features of Kauai showing a long respite from volcanic action. We consequently detect proof of but little subsidence of the islands. Moreover, there are no deep bays: and, besides, Kauai has a gently sloping coast plain of great extent, with a steep shore acclivity of one to three hundred feet, all tending to prove the smallness of the subsidence. We should, therefore, conclude that these islands lie near the limits of the subsiding area, and that the change of level was greatest at the western extremity of the range beyond Kauai.

Marquesas.—The Marquesas are remarkable for their abrupt shores, often inaccessible cliffs, and deep bays. The absence of gentle slopes along the shores, their angular features, abrupt soundings close alongside the islands, and deep indentations, all bear evidence of subsidence to some extent; for their features are very similar to those which Kauai or Tahiti would present, if buried half its height in the sea, leaving only the sharper ridges and peaks out of water. They are situated but five degrees north of the Paumotus, where eighty islands or more have disappeared, including one at least fifty miles in length. There is sufficient evidence that they participated in the subsidence of the latter, but not to the same extent. They are nearly destitute of coral.

Gambier or Mangareva Group.—In the Southern limits of the Paumotu Archipelago, where, in accordance with the foregoing views, the least depression in that region should have taken place, there are actually, as we have stated, two high islands, *Pitcairn's* and *Gambier's*. There is evidence, however, in the

extensive barrier about the *Gambier's* (see cut, vol. xiii, p. 130), that this subsidence, although less than farther north, was by no means of small amount. On page 371, vol. xi, we have estimated it at 1150 feet. These islands, therefore, although towards the limits of the subsiding area, were still far within it. The valley-bays of the Mangareva islets are of great depth, and afford additional evidence of the subsidence.

Tahitian Islands.—The Tahitian Islands, along with Samoa and the Feejees, are near the southern limits of the area pointed out. Twenty-five miles to the north of Tahiti, within sight from its peaks, lies the coral island Tetuaroa, a register of subsidence. Tahiti itself, by its barrier reefs, gives evidence of the same kind of change; amounting, however, as we have estimated, to a depression of but two hundred and fifty or three hundred feet. The northwestern islands of the group lie more within the coral area, and correspondingly, they have wider reefs and channels, and deep bays, indicating a greater amount of subsidence.

Samoa.—The island of Upolu has extensive reefs, which, in many parts, are three-fourths of a mile wide, but no inner channel. We have estimated the subsidence at one or two hundred feet. The volcanic land west of Apia declines with an unbroken gradual slope of one to three degrees beneath the sea. The absence of a low cliff is probable evidence of a depression, as has been elsewhere shown. The island of Tutuila has abrupt shores, deep bays and little coral. It appears probable, therefore, that it has experienced a greater subsidence than Upolu. Yet the central part of Upolu has very similar bays on the north, which would afford apparently the same evidence; and it is quite possible that the facts indicate a sinking which either preceded the ejections that now cover the eastern and western extremities of Upolu, or accompanied this change of level. Savaii has small reefs, from which we gather no certain facts bearing on this subject. East of Tutuila is the coral island, Rose. It may be therefore, that the greatest subsidence in the group was at its eastern extremity.

Feejee Islands.—We have already remarked upon this group. A large amount of subsidence is indicated by the reefs in every portion of the group, but it was greatest beyond doubt in the northeastern part.

Ladrones.—The Ladrones appear to have undergone their greatest subsidence at the north extremity of the range, the part nearest the centre of the coral area: for although the fires at the north have continued longest to burn, the islands are the smallest of the group, the whole having disappeared except the summits, which still eject cinders. The southern islands of the group have wide reefs, but they afford no good evidence of any great extent of subsidence since the reefs began to form.

We have thus followed around the borders of the coral area: and besides proving the reality of the limits, have ascertained some facts with reference to a gradual diminution of the subsidence towards and beyond these limits. A line from Pitcairns to Bird in the Hawaiian Group appears to have a corresponding position on the northeast with the southern boundary line of the coral area; the two include a large triangular area. An axis nearly bisecting this triangular space, drawn from Pitcairns towards Japan, actually passes through the region of greatest subsidence, as we have before determined it, and may be considered the *axial line* or *line of greatest depression* for the great area of subsidence.

It is worthy of special note, *that this axial line or line of greatest depression coincides in direction with the mean trend of the great ranges of islands, it having the course* N. 52° W.

The southern boundary line of the coral area, as we have laid it down, lies within the area of subsidence, although near its limits. There are places along this line where this area has been prolonged farther than elsewhere. One of these regions lies between Samoa and Rotuma, and extends down to the Feejees and Tonga Group; another is east of Samoa, reaching towards the Hervey Group. Each of these extensions trends parallel with the groups of islands; and with the part of the line east of Tahiti. It would seem, therefore, that the Society and Samoa islands were regions of less change of level than the deep seas about them.

What may be the Extent of the Coral Subsidence?—It is very evident that the sinking of the Society, Samoan, and Hawaiian Islands has been small compared with that required to submerge all the lands on which the Paumotus and the other Pacific atolls rest. One, two, or five hundred feet could not have buried all the many peaks of these islands. Even the 1500 feet of depression at the Gambier Group is shown to be at a distance from the axis of the subsiding area. The groups of high islands above mentioned contain summits from 4000 to 14,000 feet above the sea; and can we believe it possible that throughout this large area, when the two hundred islands now sunk were above the waves, there were none equal in altitude to the mean of these heights? That all should have been within nine thousand feet in elevation, is by no means probable. However moderate our estimate, there must still be allowed a sinking of several thousand feet: and however much we increase it within probable bounds, we shall not arrive at a more surprising change of level than our continents show that they have undergone.

Between the New Hebrides and Australia the reefs and islands mark out another area of depression, which may have been simultaneously in progress. The long reef of one hundred and fifty miles from the north cape of New Caledonia and the wide barrier

on the west cannot be explained without supposing a subsidence of one or two thousand feet at the least. The distant barrier of New Holland is proof of as great if not greater subsidence.

Effect of the Subsidence.—The facts surveyed give us a long insight into the past, and exhibit to us the Pacific scattered over with lofty lands where there are now only humble monumental atolls. Had there been no growing coral, the whole would have passed without a record. These permanent registers, planted ages past in various parts of the tropics, exhibit in enduring characters the oscillations which the "stable" earth has since undergone. Thus Divine wisdom creates and makes the creations inscribe their own history; and there is a noble pleasure in deciphering even one sentence in this Book of Nature.

From the actual extent of the coral reefs and islands, we know that the whole amount of high land lost to the Pacific by the subsidence, was at least fifty thousand square miles. But since atolls are necessarily smaller than the land they cover, and the more so, the farther subsidence has proceeded;—since many lands from their abrupt shores, or through volcanic agency must have had no reefs about them, and have disappeared without a mark; and others may have subsided too rapidly for the corals to retain themselves at the surface; it is obvious that this estimate is far below the truth. It is apparent that in many cases, islands now disjoined, have been once connected, and thus several atolls may have been made about the heights of a single subsiding land of large size. Such facts show farther error in the above estimate, evincing that the scattered atolls and reefs do not tell half the story. Why is it, also, that the Pacific islands are confined to the tropics, if not that beyond thirty degrees the zoophyte could not plant its growing registers?

Yet we should beware of hastening to the conclusion that a continent once occupied the place of the ocean, or a large part of it, which is without proof. To establish the former existence of a Pacific continent is an easy matter for the fancy; but geology knows nothing of it, nor even of its probability.

The island of Banabe in the Caroline archipelago affords evidence of a subsidence *in progress*, as my friend, Mr. Horatio Hale, the Philologist of the Expedition, gathered from a foreigner who had been for a while a resident on this island. Mr. Hale remarks, after explaining the character of certain sacred structures of stone: "It seems evident that the constructions at Ualan and Banabe are of the same kind, and were built for the same purpose. It is also clear that when the latter were raised, the islet on which they stand was in a different condition from what it now is. For at present they are actually in the water; what were once paths, are now passages for canoes, and as O'Connell [his informant] says, 'when the walls are broken down the water enters the inclos-

ures.'" Mr. Hale hence infers "that the land, or the whole group of Banabe, and perhaps all the neighboring groups, have undergone a slight depression." He also states respecting a small islet near Ualan, "From the description given of Leilei, a change of level of one or two feet would render it uninhabitable, and reduce it, in a short time, to the same state as the isle of ruins at Banabe."

Period of the subsidence.—The period during which these changes were in progress, was probably since the tertiary epoch. In the island of Metia, elevated over two hundred feet, the corals below were the same as those now existing, as far as we could judge from the fossilized specimens. At the inner margin of shore reefs, there is the same identity with existing genera. We do not claim to have examined the basement of the coral islands, and offer these facts as the only evidence on this point that is within reach. We cannot know with absolute certainty that the present races of zoophytes may not be the successors of others of the secondary epoch: but we do know that we have little reason in facts observed for even the suspicion. For a long time volcanic action was too general and constant for the growth of corals: and this may have continued to interfere till a comparatively late period, if we may judge from the appearance of the rocks, even on Tahiti.

The evidence of subsidence from coral islands might be pursued to other regions in other seas; but we here only refer to the facts on this point presented in our review of the geographical distribution of corals, (xiii, 338,) since we cannot speak from personal observation.

The subsidence has probably for a considerable period ceased in most if not all parts of the ocean, and subsequent elevations of many islands and groups have taken place which we shall soon consider. In some of the Northern Carolines, the Pescadores, and perhaps some of the Marshall Islands, the proportion of dry land is so very small compared with the great extent of the atoll, that there is reason to suspect a slow sinking even at the present time: and it is a fact of special interest in connection with it that this region is near the axial line of greatest depression, where, if in any part, the action should be longest continued.

Among the Kingsmills and Paumotus there is no reason whatever for supposing that a general subsidence is still in progress; the changes indicated are of a contrary character.

The results to which we have here been led obviously differ in many particulars from the deductions of Mr. Darwin.

2. *Elevations of Modern Eras in the Pacific.*

Since the period of subsidence, the history of which has occupied us in the preceding pages, there has been no equally general

elevation. Yet various parts of the ocean bear evidence of changes confined to particular islands or groups of islands. While the former exemplify one of the grander events in the earth's history, in which a large segment of the globe was concerned, the latter exhibit its minor changes over limited areas. The instances of these changes are so numerous and so widely scattered, that they convince us of a cessation in the previous general subsidence.

The most convenient mode of reviewing the subject is to state in order, the facts relating to each group.

a. Paumotu Archipelago.—The islands of this archipelago appear in general to have that height which the ocean may give to the materials. Nothing was detected which satisfied us of any *general* elevation in progress through the archipelago. The large extent of wooded land shows only that the islands have been long at their present level: and on this point our own observations confirm those of Mr. Darwin. There are examples of elevation in particular islands however, some of which are of unusual interest. The instances examined by the Expedition, were Honden (or Henuake), Dean's Island (or Nairsa), Aurora (or Metia), and Clermont Tonnerre. Beside these, Elizabeth Island has been described by Beechey, and the same author mentions certain facts relating to Ducie's Island and Osnaburgh, which afford some suspicions of a rise.

Honden or Dog Island.—This island is wooded on its different sides, and has a shallow lagoon. The beach is eight feet high and the land about eleven. There are three entrances to the lagoons, all of which were dry at low water, and one only was filled at high water. Around the lagoon, near the level of high tide, there were numerous shells of Tridacna lying in cavities in the coral rock, precisely as they occur alive on the shore reef. As these Tridacnas evidently lived where the shells remain, and do not occur alive more than six or eight inches, or a foot at the most, above low tide, they prove, in connection with the other facts, an elevation of *twenty inches* or *two feet.*

Nairsa or Dean's Island.—The south side of Dean's island, the largest of the Paumotus, was coasted along by the Peacock, and from the vessel we observed that the rim of land consisted for miles of an even wall of coral rock, apparently six or eight feet above high tide. This wall was broken into rude columns, or excavated with arches and caverns; in some places the sea had carried it away from fifty to one hundred rods and then there followed again a line of columns and walls, with occasional arches as before. The reef, formerly lying at the level of low tide, had been raised above the sea, and subsequently had undergone degradation from the waves. The standing columns had some resemblance in certain parts to the masses seen here and there on the

shore platforms of other islands; but the latter are only distantly scattered masses, while on this island, for the greater part of the course, there were long walls of reef-rock. The height moreover was greater, and they occurred too on the *leeward* side of the island, ranging along nearly its whole course.

The elevation here indicated was at least *six feet;* but it may have been larger, as the observations were made from ship-board. Thirty miles to the southward of Dean's Island, we came to Metia, one of the most remarkable examples of elevation in the Pacific.

Metia.—This island has already been described, and its elevation stated at *two hundred and fifty feet.* (See xii, 40.)

*Clermont Tonnerre,** according to Mr. Couthouy, shows the same evidence of elevation from Tridacnas as Honden Island. Clermont Tonnerre and Honden are in the northeastern limits of the Paumotus.

Elizabeth Island was early shown to be an elevated coral island by Beechey. This distinguished voyager represents it as having perpendicular cliffs fifty feet in height. From his description, it is obviously of the same character as Metia; the elevation is *eighty* feet.

Ducie's Island is described by Beechey as twelve feet high, which would indicate an elevation of at least *one* or *two* feet.

Osnaburgh Island, according to the same author, affords evidence of having increased its height since the wreck of the Matilda in 1792. He contrasts the change from "a reef of rocks," as reported by the crew, to "a conspicuously wooded island," the condition when he visited it; and states further, that the anchor, iron-works, and a large gun (4-pounder) of this vessel were two hundred yards inside of the line of breakers. Captain Beechey suggests that the coral had grown, and thus increased the height. But this process might have buried the anchor if the reef were covered with growing corals, (which is improbable,) and could not have raised its level. If there has been any increase of height, (which we do not say is certain,) it must have arisen from subterranean action.

b. Tahitian Group.—The island of Tahiti presented us no conclusive evidence of elevation. The shore plains are said to rest on coral, which the mountain debris has covered; but they do not appear to indicate a rise of the land. The descriptions by different authors of the other islands of this group, do not give sufficient reason for confidently believing that any of them have been elevated. The change, however, of the barrier reef around Bolabola into a verdant islet encircling the island, may be evi-

* This island was not visited by the writer, as only the officers of the Vincennes attempted to land on it.

dence that a long period has elapsed since the subsidence ceased; and as such a change is not common in the Pacific, we may suspect that it has been furthered by at least a small amount of elevation. The observation by the Rev. D. Tyerman with regard to the shells found at Huahine high above the sea, may be proof of elevation; but the earlier erroneous conclusions with regard to Tahiti, teach us to be cautious in admitting it without a more particular examination of the deposit.

c. Hervey and Rurutu Groups.—These groups lie to the southwest and south of Tahiti.

Atiu (Wateoo of Cook) is a raised coral island. Cook observes that it is "nearly like Mangaia." The land near the sea is only a bank of coral ten or twelve feet high, and steep and rugged. The surface of the island is covered with verdant hills and plains, with no streams.*

Mauke is a low elevated coral island.†

Mitiaro resembles Mauke.‡

Okatutaia is a low coral island, not more than six or seven feet high above the beach, which is coral sand. It has a light-reddish soil.

Mangaia is girted by an elevated coral reef *three hundred* feet in height. Mr. Williams speaks of it as coral, with a small quantity of fine-grained basalt in the interior of the island; he states again that a broad ridge (the reef) girts the hills.§

Rurutu has an elevated coral reef *one hundred and fifty* feet in height.‖

With regard to the other islands of these groups, *Manuai*, *Aitutaki*, *Rarotonga*, *Rimetara*, *Tubuai*, and *Raivavai*, the descriptions by Williams and Ellis appear to show that they have undergone no recent elevation.

d. Scattered Islands in the latitudes between the Society and Samoan Groups.—These coral islands, as far as we can ascertain, are low like the Paumotus, excepting some of the Fanning Group north of the equator, and possibly Jarvis and Malden.

Of the *Fanning Group*, (situated near the equator, south of the Hawaiian Group,)

Washington Island is three miles in diameter, without a proper lagoon; the whole surface, as seen by us, was covered densely

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* Cook's Voyage, vol. i, pp. 180, 197. Williams's Miss. Enterprises, i, 47, 48, first Am. edit., Appleton.

† Williams's Miss. Ent., pp. 39, 47, 264. ‡ Ibid. pp. 39, 264.

§ Williams's Miss. Ent., pp. 48, 50, 249. See also Mr. Darwin, p. 132.

‖ Williams's Miss. Ent., p. 50.—Stutchbury describes the coral rock as one hundred and fifty feet high. West of England Journal, i.—Tyerman and Bennet describe the island as having a high central peak with lower eminences, and speak of the coral rock as two hundred feet high on one side of the bay and three hundred on the other (ii, 102).—Ellis says that the rocks of the interior are in part basaltic, and in part vesicular lava, iii, 393.

with cocoanut trees. This unusual size for an island without a lagoon indicates an elevation, which the height of the island, estimated at twelve feet, confirms. The elevation may have been *two* or *three* feet.

Palmyra Island, just northwest of Washington, is described by Fanning as having two lagoons; the westernmost contains twenty fathoms water. *Fanning's Island*, to the southeast of Washington, is described by the same voyager as lower than that island. The accounts give no evidence of elevation.

Christmas Island, still farther to the southeast, according to the description of Cook, its discoverer, had the rim of land in some parts three miles wide. He mentions narrow ridges lying parallel with the sea-coast, which "must have been thrown up by the sea, though it does not reach within a mile of some of these places." The proof of a small elevation is decided, but its amount cannot be determined from the description. The account of F. D. Bennett, (Geographical Jour., vii, 226,) represents it as a low coral island.

Jarvis Island, as seen from the Peacock, appeared to be eighteen or twenty feet in height, which, if not exaggerated by refraction, (we think it not probable,) would show an elevation of six or eight feet. This island is a sand flat, with little vegetation, and is but two hundred miles south of Christmas Island.

Malden, two hundred and fifty miles southeast of Jarvis, near latitude 4° S. and longitude 155° W., visited by Lord Byron, is described as not over forty feet high; but this may be the whole height, including the height of the trees.

e. Tonga Islands and others in their vicinity.

All the islands of the Tonga group about which there are reefs, give evidence of elevation: *Tongatabu* and the *Hapai* islands consist solely of coral, and are elevated atolls.

Eua, at the south extremity of the line, has an undulated, mostly grassy surface, in some parts eight hundred feet in height. Around the shores, as was seen by us from shipboard, there is an elevated layer of coral reef-rock, twenty feet thick, worn out into caverns, and with many spout-holes. Between the southern shores and the highest part of the island, we observed three distinct terraces. Coral is said to occur at a height of three hundred feet. From the appearance of the land, we judged that the interior was basaltic; but nothing positive was ascertained with regard to it.

Tongatabu (an island visited by us) lies near Eua, and is in some parts fifty or sixty feet high, though in general but twenty feet. It has a shallow lagoon, into which there are two entrances; some hummocks of coral reef-rock stand eight feet out of water.

Namuka and most of the *Hapaii* cluster, are stated by Cook to have abrupt limestone shores, ten to twenty feet in height.

Namuka has a lagoon or salt lake at centre one and a half miles broad; and there is a coral rock in one part twenty-five feet high.*

Vavau, the northern of the Group, according to Williams, is a cluster of elevated islands of coral limestone, thirty to one hundred feet in height, having precipitous cliffs, with many excavations along the coast.†

Pylstaart's Island, south of Tongatabu, is a small rocky islet without coral. Tafua and Proby are volcanic cones, and the former is still active.

Savage Island, a little to the east of the Tonga Group, resembles Vavau in its coral constitution and cavernous cliffs. It is elevated *one hundred feet.*‡

Beveridge Reef, a hundred miles southeast of Savage, is low coral.

f. Samoan Islands.—No satisfactory evidences of elevation were detected about these islands.

g. Scattered Islands, north of Samoa.

These islands are all of coral, and several indicate an elevation of one to six feet. On account of the high tides, (4 to 6 feet,) the sea may give a height of ten or twelve feet to the land.

Swain's, near latitude 11° S., is fifteen to eighteen feet above the sea, where highest, and the beach is ten to twelve feet high. It is a small island, with a depression at centre, but no lagoon. The height proves an elevation of *three to six* feet.

Fakaafo, ninety miles to the north, is fifteen feet high. The coral reef-rock is raised in some places three feet above the present level of the platform. Elevation at least *three* feet.

Nukunono, or Duke of Clarence, near Fakaafo, was seen only from shipboard.

Oatafu, or Duke of York's, is in some parts fourteen feet high. Elevation *two* or *three* feet.

Enderby's and *Birnie's*, still farther north, are twelve feet high. Judging from the double slope of the beach on Enderby, this island may have undergone an elevation of *two* feet, the height of the upper slope; yet we think it doubtful.

Gardner's, *Hull*, *Sydney* and *Newmarket* were visited by the Expedition, but no satisfactory evidences of elevation on the first three were observed. The last is stated by Captain Wilkes to be *twenty-five* feet in height.

h. Feejee Islands.—The proofs of an elevation of four to six feet about the larger Feejee Islands, Viti Lebu and Vanua Lebu, and also Ovalau, are given in our report on this group. How

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* Cook's Voyage.—Williams, p. 296. † Williams, p. 427.

‡ Williams, pp. 275, 276. Foster estimates the height at fifty feet, and speaks of a depression about the centre.

far this rise affected other parts of the group, I have been unable definitely to determine: but as the extensive barrier reefs in the eastern part of the group, rarely support a green islet, they rather indicate a subsidence in those parts than an elevation.

i. Islands north of the Feejees.—Horne Island, Wallis, Ellice, Depeyster, and four islands on the track towards the Kingsmills, were passed by the Peacock; but from the vessel, no evidences of elevation could be distinguished. The first two are high islands, with barriers, and the others are low coral. ***Rotuma***, (177° 15′ E., and 12° 30′ N.,) is another high island, to the west of Wallis's. It has encircling reefs, but we know nothing as to its changes of level.

k. Sandwich Islands.—***Oahu*** affords decided proof of an elevation of twenty-five or thirty feet. There is an impression at Honolulu, derived from a supposed increasing height in the reef off the harbor, that the island is slowly rising. Upon this point I can offer nothing decisive. The present height of the reef is not sufficiently above the level to which it might be raised by the tides, to render it certain, from this kind of evidence, that the suspected elevation is in progress.

Kauai presents us with no evidence that the island, at the present time, is at a higher level than when the coral reefs begun: or at the most, no elevation is indicated beyond a foot or two. The drift sand rock of Koloa appears to be a proof of elevation, from its resemblance to those of Northern Oahu: but if so, there must have been a subsidence since, as it now forms a cliff on the shore that is gradually wearing away.

Molokai, according to information from the Rev. Mr. Andrews, has coral upon its declivities three hundred feet above the sea. The same gentleman informed us that on the western peninsula of ***Maui***, coral occurs in some places eight hundred feet above the sea; and specimens of well defined coral were obtained at a height of five hundred feet. These islands were not visited by the writer.

With regard to ***Molokai***, Mr. Andrews informed the author that the coral occurs "upon the acclivity of the eastern or highest part of the island, over a surface of more than twenty or thirty acres, and extends almost to the sea. We had no means of accurately measuring the height; but the specimens were obtained at least three hundred feet above the level of the sea, and probably four hundred. The specimens have distinctly the structure of coral. The distance from the sea was two to three miles."

Mr. Andrews, who appears to doubt the connection of the supposed coral on ***Maui*** with reefs, writes to the author as follows: "In no case have I seen the coral in a rocky ledge; it is generally mixed with the lava rock, to which it adheres. It has

usually the appearance of burnt lime; and thus, large stones and rocks seem as though they had been whitewashed several times over, and sometimes it amounts to an inch in thickness, or an inch and a half. At other times the whitewash has found its way into cracks in the stones. Sometimes only one side of a stone is whitened by it, or only a corner of it. It is sometimes soft and crumbly, and at other times quite hard; and again it is mixed with the earth." From this description it appears to resemble the lime incrustations and seams of Diamond Hill, Punchbowl and Koko Head, Oahu, which occur at the same height, but most certainly give no evidence of elevation, as they have proceeded beyond doubt from aqueous eruptions carrying lime in solution. Fragments of coral, it will be remembered, occur in the tufa of these hills. This evidence from Mani, should therefore be received with great hesitation until farther examined.

Besides the above, there are large masses of coral rock, according to Mr. Andrews, along the shores of Mani, from *two* to *twelve* feet above high water. From his descriptions, this rock appears to be the reef-rock, like the raised reef of Oahu, and is probably proof of an elevation of at least *twelve* feet.

l. Kingsmill or Tarawan Group. (Plate I, Vol. xii.)

Taputeouea or Drummond.—This is the southern island of the group. The reef rock near the village of Utiroa is a foot above low tide level, and consists of large massive Astreas and Meandrinas. The tide in the Kingsmill seas is seven feet; and consequently this evidence of a rise might be doubted, as some corals may grow to this height where the tide is so high. But these Astreas and Meandrinas, as far as observed by the writer, are not among the species that may undergo exposure at low tide, except it be to the amount of three or four inches; and it is probable that an elevation of at least *ten* or *twelve* inches has taken place.

Apia or *Charlotte's* Island, one of the northernmost of the group, has the *reef-rock* in some parts raised bodily to a height of six or seven feet above low water level, evidencing this amount of elevation. This elevated reef was observed for long distances between the several wooded islets; it resembled the south reef of Nairsa in the Paumotu Archipelago in its bare, even top, and bluff worn front. An islet of the atoll, where we landed, was twelve feet high, and the coral *reef-rock* was five or six feet above middle tide. A wall of this rock, having the same height extends along the reef from the islet. There was no doubt that it was due to an actual uplifting of the reef to a height of full *six* feet.

Nanouki, *Kuria*, *Maiana* and *Tarawa* lying between the two islands above mentioned, were seen only from the ship, and nothing decisive bearing on the subject of elevation was ob-

served. On the northeast side of Nanouki there was a hill twenty or thirty feet in height covered with trees; but we had no means of learning that it was not artificial. We were, however, informed by Kirby, a sailor taken from Kuria, that the reef of *Apamama* was elevated precisely like that of Apia, to a height of *five* feet; and this was confirmed by Lieutenant Dehaven, who was engaged in the survey of the reef. We were told, also, that Kuria and Nanouki were similar in having the reef elevated though to a less extent. It would hence appear that the elevations in the group increase to the northward.

Maraki, to the north of Apia, is wooded throughout. We sailed around it without landing, and can only say that it has probably been uplifted like the islands south. *Makin*, the northernmost island, presented in the distant view no certain evidence of elevation.

The elevation of the Kingsmills accounts for the long continuity of the wooded lines of land, an unusual fact considering the size of the islands. The amount of fresh water obtained from springs is also uncommon. (xii, 48.) The wear from storms would also be greater on islands which have been elevated.

m. Radack, Ralick and Caroline Islands.—No evidences of elevation in these groups are yet known. The very small amount of wooded land on the Pescadores inclines us to suspect rather a subsidence than an elevation; and the same fact might be gathered with regard to some of the islands south, from the charts of Kotzebue and Kruesenstern.

n. Ladrones.—The seventeen islands which constitute this group, may all have undergone elevations within a recent period, but owing to the absence of coral from the northern, we have evidence only with regard to the more southern.

Guam, according to Quoy and Gaymard, has coral rock upon its hills more than *six hundred* feet (one hundred toises) above the sea.

Rota, the next island north, afforded these authors similar facts, indicating the same amount of elevation.

o. Pelews and neighboring Islands.—The island *Feis*, three hundred miles southwest of Guam, is stated by Darwin, on the authority of Lutke, to be of coral, and *ninety* feet high. *Mackenzie* Island, seventy-five miles south of Feis, is a low atoll, as ascertained by the Expedition. No evidences of elevation are known to occur at the Pelews.

Melanesian Islands.—Among the New Hebrides, New Caledonia, Salomon Islands, the evidences of elevation have not yet been examined.

The details given on the preceding pages are presented in a tabular form on the next page.

		FEET.
Paumotu Archipelago,	Honden,	1½ or 2
" "	Clermont Tonnere,	2
" "	Nairsa or Deans's,	6
" "	Elizabeth,	80
" "	Metia or Aurora,	250
" "	Ducie's,	1 or 2
Tahitian Group,	Tahiti,	0?
" "	Bolabola,	?
Hervey and Rurutu Groups,	Atiu,	12?
" " " "	Mauke,	somewhat elevated.
" " " "	Mitiaro,	" "
" " " "	Mangaia,	300
" " " "	Rurutu,	150
" " " "	Remaining Islands,	0?
North of the Tahitian,	Washington Island,	2 or 3
" " " "	Christmas,	2?
" " " "	Malden,	?
" " " "	Jarvis,	6 or 8?
Tongan Group,	Eua,	300?
" "	Tongatabu,	60
" "	Namuka and the Hapai,	25
" "	Vavau,	100
Savage Island,		100
Samoan Islands,		0
North of Samoa,	Swain's,	3 to 6
" " "	Fakaafo, or Bowditch,	3
" " "	Oatafu, or Duke of York's,	2 or 3
" " "	Enderby's,	2?
" " "	Gardner, Hull, Sidney, Newmarket,	0?
Feejee Islands,	Viti Levu and Vanua Levu, Ovalau,	5 or 6
	Eastern Islands,	0?
North of Feejees,	Horne, Wallis, Ellice, Depeyster,	0?
Sandwich Islands,	Kauai,	1 or 2
" "	Oahu,	25 or 30
" "	Molokai,	300
" "	Maui,	12—
Tarawan Islands,	Taputeouea,	1 or 2
" "	Nanouki, Kuria, Maiana and Tarawa,	2 or more.
" "	Apamama,	5
" "	Apia or Charlotte,	6 or 7
" "	Maraki,	2 or 3
" "	Makin,	0
Carolines,		none ascertained.
Ladrones,	Guam,	600
"	Rota,	600
Feis,		90
Pelews,		0?
New Hebrides, New Caledonia, Salomon Islands,		none ascertained.

Several deductions are at once obvious:—

1. That the elevations have taken place in all parts of the ocean.

2. That they have in some instances affected single islands, and not those adjoining.

3. That the amount is often very unequal in adjacent islands.

4. That in a few instances the change has been experienced by a whole group or chain of islands. The Tarawan Group is an instance, and the rise appears to increase from the southernmost island to Apia, and then to diminish again to the other extremity.

The Feejees may be an example of a rise at the west side of a group, and possibly a subsidence on the east; while a little farther east, the Tonga Islands constitute another extended area of elevation. We observe that while the Samoan Islands afford no evidences of elevation, the Tonga Islands on the south have been raised, and also the Fakaafo Group and others on the north.

We cannot, therefore, distinguish any evidence that a general rise is or has been in progress; yet some large areas appear to have been simultaneously affected, although the action has often been isolated. Metia and Elizabeth Island may have risen abruptly: but the changes of level in the Feejees and the Friendly Islands, appear to have taken place by a gradual action.

ART. XX.—*On Soleil's Saccharimeter;* by W. P. RIDDELL, A.B., New Orleans, Louisiana.

THIS instrument, so beautiful in theory, and so exact in its practical operations for the analysis of *sugars*, *syrups* and *molasses*, depends upon that peculiar property of light termed *circular polarization;* a modification first noticed by M. Arago in crystal quartz or rock crystal.*

Polarization.—The Newtonian theory of the *materiality* of light fails to give an adequate explanation of the phenomena of polarization. But, according to the *wave* or *undulatory* theory, common light is considered an *effect*, produced by the vibrations of an extremely subtile medium, termed *luminiferous ether.* These vibrations are supposed to be in three directions, in rectilinear and rectangular planes; two of which are transverse to the direction in which the ray is propagated and at right angles to each other; and the third, parallel to the direction of propagation. The existence of this third plane is inferred from the phenomenon of the dispersion of the different rays of the spectrum. But of this we need not speak particularly, as it has no essential bearing on the present subject.

Leaving out of view then this third plane, we see that we may consider common or unpolarized light to be produced by vibrations in two rectangular planes. Now if we can contrive to separate these two vibrations so as to have two rays, each being produced by vibrations in one plane only, we shall have two rays of *polarized* light, whose planes of vibration are perpendicular to each other. If again we bring these two sets of vibra-

* It might seem unnecessary to enter at all into the subject of polarization, as nothing new is offered; yet to render the following application plain, to those who have given the matter no previous study, it was thought best to offer a succinct view of the received notions respecting it.

tions *centrally* together, without changing their planes, we have, as before, *one* ray of unpolarized light, produced by vibrations in *two* rectangular planes. Thus we have a distinct idea of the difference between *polarized* and *unpolarized* light.

There are several ways in which we may thus separate these two planes and hence produce polarization: viz, by simple reflection at certain angles (differing for different substances); by single refraction, as by means of a bundle of thin glass plates; by double refraction, as by means of a crystal of Iceland or calc spar; by transmitting a ray through a plate of tourmaline, which has the property of smothering or absorbing the vibrations in one direction and permitting only those of the other plane to pass through.

Circular polarization is a condition slightly different from the above, and is produced only when rectilinear vibrations are made to interfere with each other in a particular manner: this interference does not take place when both sets of vibrations have equal velocities. But as we know that if one wave of water be half an undulation behind another of equal size, they mutually destroy each other; while the same, if of equal velocities, may vibrate in vertical, right angled planes, with no sensible interference; so may we conjecture in regard to these waves of light-bearing ether.

It may be shown in various ways, that the result of the interference of these rectilinear vibrations will be curvilinear vibrations, a movement which may be likened to "that of the extremity of the swinging pendulum," or more aptly to the spiral course of a coiled wire. If then we can *retard* the vibrations in one direction, then bring them centrally in contact with those of the other direction, they mutually interfere, and no longer, as in the case of simply polarized light, produce common light; they no longer vibrate in rectilinear planes, but in a curvilinear plane, the *result* of the two forces acting in the original rectilinear planes. By varying the amount of this retardation, we may produce *circular* or even *elliptical* waves. If this retardation amount to the one-fourth of an undulation, the waves will be circular, as can be shown by means of a very simple apparatus devised by Professor Wheatstone.

It is found that crystal quartz possesses in a high degree this power of retarding one of the two sets of vibrations; thus affording, in connection with light properly polarized, *circular polarization*. Some species of quartz exhibit what is termed right-handed polarization, hence called *dextrogyrate;* some, left-handed polarization, hence called *lævogyrate;* the distinction between which being as follows:

If we place a plate of Iceland spar, cut perpendicular to its principal or prismatic axis, in the polariscope, the polarizing and analyzing plates being crossed, we shall observe a gorgeous dis-

play of colored concentric rings intersected by a rectangular black cross, whose arms meet at the centre of the rings. In these rings we observe a succession of the seven colors of the spectrum; and some very singular changes, which need not here be described, take place when we revolve either the polarizer or analyzer. All the modifications which light undergoes in passing through certain crystals, may usually be traced to the peculiar structure or crystallization of said crystal; but quartz, which is classed in the same system of crystals with Iceland spar, gives us quite a different result when placed in the polariscope. We observe a system of prismatic rings, but the black cross in the centre is not there, and in its place we have a certain uniform tint the hue of which changes successively through the whole range of the spectrum, when either the analyzer or polarizer is revolved; for right-handed quartz, if we revolve the analyzer to the right, the colors will be seen to succeed each other in the following order: *red*, *orange*, *yellow*, *green*, *blue*, *indigo*, *violet*, *red*, and so on; while for the left-handed quartz they will be seen to succeed each other in the contrary order, viz.: *red*, *violet*, *indigo*, *blue*, *green*, *yellow*, *orange*, *red*, and so on; hence to obtain the same order of succession as in the first case we must revolve the analyzer in the opposite direction, or to the left. Therefore the first kind of quartz is called *dextrogyrate*, the second *lævogyrate*. The width of this central hue, as well as that of the concentric circles, will depend upon the thickness of the plate of quartz employed, the diameter of the rings being, it is said, inversely as the square root of the thickness of the film of quartz.

As circular polarization is supposed to result from two sets of rectilinear vibrations centrally joined, acting in rectangular planes one of the sets being *retarded*, so colors are supposed to result from two sets of rectilinear vibrations, one of which is retarded, but both of which act in the *same plane*.

The application of the foregoing principles for the purposes of analysis comes next to be explained. If we take two plates of tourmaline, (which by the way must be cut in planes parallel to the axis of crystallization,) place them parallel, one with its axis in a vertical, the other with its axis in a horizontal position; then permit a ray of common light to strike perpendicular upon them,—the first will stifle all except the vertical vibrations, while the second will stifle all except the horizontal ones; hence no light will be permitted to pass through both plates thus placed.

This position of the two plates of tourmaline, viz.: so as to extinguish the light, is termed the *azimuth zero*, or point of greatest obscuration. If now we place between these two plates a piece of quartz, or any other circularly polarizing substance, the effect is immediately noticed from the fact that the light which was before obscured by the two tourmaline plates is now seen to

pass through the three,—and in order to reëstablish the *azimuth zero*, it is necessary to revolve the analyzer, either to the right or left as the case may be, through a certain number of degrees, according to the thickness of the interposed quartz. If instead of the plate of tourmaline, a double refractor be employed for a polarizer, a similar result is observable, except that instead of totally shutting out the light at the azimuth zero, we are only able to exclude one image, usually the *extraordinary;* and so to rëestablish the azimuth zero, we only seek to exclude one of the images, both having been rendered visible by the interposition of the quartz; this we do as in the other case, by revolving either the analyzer or polarizer. The angle through which it is necessary to revolve the analyzer has been found proportionate to the thickness of the quartz; or if two plates of quartz be interposed, the angle of variation will be as the *sum* of the two thicknesses, if both be right-handed, or both left-handed; or as the *difference*, if one be right and the other left: and the same in regard to all *circularly* polarizing substances.

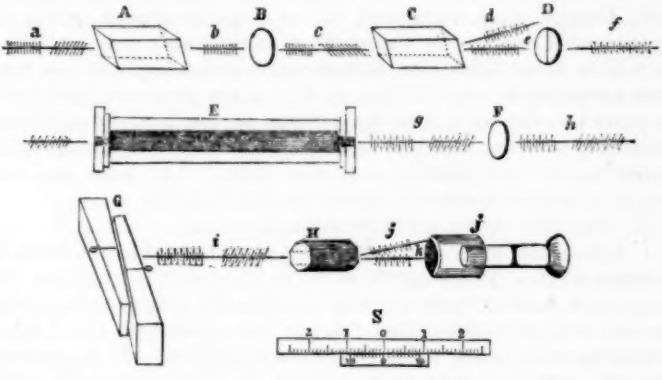
We can then at once, get a glimpse of the extended application of which this singular principle is susceptible.

In the earlier instruments constructed on this principle, for the analysis of sugars, &c., the only parts were the *polarizer*, the *tube of observation*, and the *analyzer;* and the amount of sugar was estimated from the number of degrees through which it was necessary to revolve the analyzer in order to reëstablish the *azimuth zero;* but it was found no easy matter to judge as accurately as was desirable as to this point of greatest obscuration, for the analyzer had to be revolved over several degrees before any change could be observed.

A second step was taken by substituting a ray of *homogeneous* light; but still it was found exceedingly difficult to distinguish, with a precision sufficiently constant and exact, the precise *limit* of each color; for they seem to flow so readily into each other, and besides, of themselves, have something of a margin on the spectrum. This defect is very ingeniously surmounted in the instrument of Soleil, by placing side by side two plates of quartz, one left-handed, the other right-handed; so that any difference is not only doubled, but instead of judging of the *identity* of any certain abstract hue, we have only to *identify*, by means of the compensator, the hues of two juxtaposed semi-discs.

Soleil's Saccharimeter.—We have now taken a general view of the principles on which saccharimetry, by means of circular polarization, depends. It remains briefly to speak of the instrument constructed by Soleil of Paris, (which I think undoubtedly deserves the first place,) and describe somewhat more minutely the process of actual analysis by means of it.

The instrument, of which I propose to give a very brief description, was brought from Paris by the Hon. J. P. Benjamin, of New Orleans, and now belongs to Prof. J. L. Riddell, of the University of Louisiana. It consists of the following parts, commencing at the extremity farthest from the eye of the observer when making an analysis:—



A, Polarizer, a Nicol's Prism, admitting only one of the polarized rays to pass through.

B, Depolarizer, being a plate of right-handed quartz, cut perpendicular to the axis of its crystallization.

C, the polarizer proper, or analyzer as related to A and B, whose functions are only to produce any desired tint by merely revolving; which is accomplished by means of a thumb-screw, close to the thumb-screw of the compensator.

D, Biquartz, composed of two juxtaposed plates of quartz, of equal thickness, but of contrary rotative power, one being right-handed, the other left-handed; by which the difference observed in the tints of the semi-discs, when the right- and left-handed rotations in the instrument are not in equilibrio, are doubled, since the tints as observed through the one semi-disc succeed each other in the opposite order to what they do as seen through the other.

E, Tube of observation, 20 and 22 centimeters long, into which the liquid to be analyzed is poured, and closed by means of glass plates, which are held in their place by brass caps closely fitted, as it is very essential that every bubble of air should be excluded; when the tube has been filled with the saccharine liquid and replaced in its proper position in the instrument, the tints of the two halves of the ordinary and extraordinary disc will be seen to be different and complementary for the reason already noticed, but can be brought to a uniform tint, as at starting,

by means of the compensator; and the *direction* in which the compensator has to be moved determines the quality of rotation; the *distance* over which it has to be moved determines the quantity or amount of that rotation.

F, plate of left-handed quartz, equivalent in thickness to the two plates of the compensator, G, when set at zero; and its object is to equilibrate the opposite effect of said compensator.

G, Compensator, composed of two wedge-shaped plates of right-handed quartz, the thickness of whose *sum* may be varied by sliding their *thicker* or *thinner* extremities together; at zero their thickness is equal to that of F. If the principal part has to be moved to the right, and the vernier to the left, the specimen under examination exerts a rotary influence to the right, and is consequently *right-handed*, and *vice versa*. The scale and vernier of this compensator is shown separately at S.

H, Analyzer, being a double refracting prism.

J, Eye-piece, with two adjustable lenses, to fit the focus to different eyes. The progress of a ray of common light (*a*) striking upon A, is as follows:—By A it is polarized, so as to vibrate in only one rectilinear plane, (*b*,) as the vibrations in all other planes are smothered. By B this polarized ray (*b*) is resolved into two sets of rectangular vibrations, (*c*,) one of which is retarded: by C these again are resolved into two systems of rectilinear, rectangular vibrations, (*d* and *e*,) one set of each system being *retarded*, hence colored rays, one of which (*e*) only is received through D. By E the tint of this colored ray is changed, and must be restored by G. The effect of F and G, being equivalent, and mutually neutralizing, may be counted as nothing. By H the color of the rays is made visible, by bringing the vibrations in a position so as to interfere in the same plane, which is necessary for the production of colored light.

On the scale of the compensator, G, the figures 1 and 2 correspond to quartz of an opposite polarization, whose thickness is 1 and 2 millimetres, and are read 100 and 200 degrees. The smaller divisions are read 10 degrees each, while single degrees are read by means of the vernier. The degrees therefore correspond nearly to $\frac{1}{4}^{\circ}$ in the deviation of the *plane* of polarization.

Among substances which exercise an influence on the polarizing apparatus, the most important, according to Pereira, are:

Volatile oils (those of mustard and bitter almond excepted).

Naphtha.

Aqueous solutions of several kinds of *sugar*, *dextrine*, tartaric acid and tartrates (tartrate of *alumina* excepted).

Diabetic urine.

Albuminous urine.

Alcoholic solutions of *camphor* and *artificial camphor.*

Most *vegetable juices.*

While as devoid of this property, we may enumerate *water*, *alcohol*, *pyroxylic spirit*, *pyroacetic spirit*, *olive oil*, *claret wine*, (with perhaps a trace of left-handed polarization,) *champagne*, *citric acid*, *mannite*, *liquorice sugar*, *glycerine*, *&c.*

It will be seen from the above that sugars of different kinds exert different effects in connection with polarization. These effects Mr. Pereira classes as follows:

1. *Cane sugar*, ... *Right-handed.*
2. *Grape sugar*, (Glucose of Dumas,) . . " "
3. *Uncrystallizable sugar*, (Chulariose of Soubeiran.)
   Uncrystallizable sugar of honey, . . . *Left-handed.*
   Uncrystallizable sugar obtained by the action of acids on cane sugar, . . . " "
   Uncrystallizable sugar of the juice of fruits, " "
   Uncrystallizable sugar obtained by the alteration of cane sugar. This constitutes the greater part of molasses, . . . " "
4. *Mannite*, 5. *Glycerin*, *and* 6. *Liquorice sugar*, 0 (zero).

Process of Analysis.—Make the zeros of the compensator (on the scale and on the vernier) correspond perfectly; then revolve the analyzer by means of the thumb-screw until the *semi-discs* have one and the same *uniform* tint; the two *discs* will then be observed to have complementary colors: thus, if the ordinary *disc* or *image* be *violet*, the extraordinary one will be *yellow;* if the former be red, the latter will be green, &c. The focus of the eye-piece may either be adjusted now, or after the liquor is introduced into the observation tube; this is done by adjusting the distance between the two lenses, to suit different eyes while looking through the instrument: if done before the liquor is introduced, water should be placed in the tube, because the focus will vary somewhat if the tube be empty.

For *brown sugar* and *molasses*, an analysis is effected by comparing the rotating power of a solution of known degree of dilution, with the rotating power of a standard *normal* solution. From the specimen which we wish to analyze (whether molasses or sugar) we weigh, by means of special weights accompanying Clerget's apparatus, 16·471 grammes; place this in a matrass graduated on the neck to 100 and 110 cubic centimetres: pour in water till the matrass is filled to the 100 c. c. mark. If the mixture be sufficiently transparent, submit it to *observation* in the tube of 20 centimetres length, and note the degree of *deviation* by means of the degrees marked on the compensator, in the way before described. But if not, complete the filling of the matrass to the 110 c. c. mark, by pouring in either sub-acetate of lead, or fish glue and alcohol; if the latter, first introduce 5 c. c. of a solution of fish glue, and then the other 5 c. c. of alcohol. The defecating agent must be mixed thoroughly with the liquor and allowed

to stand two or three minutes, then thrown upon the filter. If now the mixture be too highly colored to admit of observation, it must be discolored by filtration through *bone-black*, or *animal charcoal;* special tubes for which are provided in Clerget's very full and beautiful set of apparatus, which usually accompanies the Saccharimeter. The process will require one hour, and possibly the liquor may have to be passed through the bone-black several times. It must be remembered however, that the first portions (a quantity about equal to the volume of bone-black) which come through the bone-black, must not be employed in the observations, as it is found that the bone-black, until a little saturated, weakens the solution. The liquor is next introduced into the tube of observation, and the rotation noted as before by turning the thumb-screw of the compensator till the two semi-discs again exhibit a uniform tint. If, previous to filtering through the bone-black, the *defecating agent* has been used, the tube of 22 centimeters must be employed to compensate for the consequent dilution; but if the defecating agent has not been used, the tube of 20 centimetres must be employed. It will be observed that using the tube of 22 centimetres is the same in effect as adding $\frac{1}{10}$th to the strength of the solution as determined in the tube of 20 centim.

The number of degrees of rotation as read on the scale of the compensator, will give the actual *per cent* of *pure* sugar in the sample. The scale is so graduated that if we had weighed 16·471 grammes of *pure sugar*, and formed our solution in the same way, by means of the matrass graduated to 100 c. c., the rotation as indicated by the degrees of the compensator, would be 100°. Hence any proportional number of degrees of rotation will indicate a corresponding proportional amount of saccharine matter as compared to pure sugar. Or, since the *normal* or *standard* solution contains 164·71 grammes of pure sugar per litre, we may multiply the number of degrees of rotation of any solution by 164·71, and divide the product by 100, and we shall obtain the number of grammes of pure sugar contained in the litre of our sample solution.

The above method is all that is necessary in solutions which contain no *left-handed* sugar, and nothing which may interfere with the legitimate action of the *right-handed* cane sugar, the determination of which is the usual object of analytical research. But since brown sugars, and especially molasses, invariably contain other substances which exert a polarizing influence sometimes to the right, sometimes to the left, it is desirable to disengage the influence of the same from the influence *due* to the *cane sugar*. For this purpose we perform what is termed the

Process of inversion, which affects the polarizing power of the cane sugar *only;* but which changes this from *right-hand* to *left-hand* sugar. It is accomplished in the following manner:

From the solution prepared, (defecated and decolorized, if necessary, as explained,) fill a small matrass to the mark on the neck indicating a capacity of 50 c. c., complete the filling of the matrass to the mark on the neck indicating a capacity of 55 c. c., by pouring in strong hydrochloric acid; place the matrass in a water bath kept uniformly at a temperature of 68° Centigrade, continue it there for 15 minutes, and the inversion will be complete. Throw this upon a paper filter, and allow the liquid to flow directly into the tube of 22 centim. length, which is provided with a special *upright* tube for determining the temperature which exerts a considerable influence on the rotatory power of inverted liquids, and must be carefully noted; it is better to make the observations at some uniform temperature, as for instance 28° or 30° Centigrade.

If the rotation be to the left, *add* it to the rotation to the right determined previous to the inversion; if the rotation be still to the right, *subtract* it from the right-handed rotation previously determined. In the table, which accompanies Clerget's apparatus, under the temperature corresponding to the temperature at which the observation after inversion has been made, seek the number corresponding to the *sum* or *difference* of the degrees of rotation determined by the observation, follow to the right hand the line of horizontal figures to the column marked A, in which will be found the figures expressing the *per cent.* by weight of sugar in the sample; or continue to the column marked B, in which will be found the figures expressing the number of grammes *per litre* contained in the given liquid. Either of these will express the *title* of sample under analysis—the former gives the title by *weight*, the latter, by *volume*.

Mr. Clerget, in his "Memoire à la Société d'Encouragement," on the analysis of sugars, &c., (where a very full description of the apparatus, &c. used in analysis is given,) recommends the following preparation of fish-glue: macerate in cold water (near 25 centiliters) for about 30 hours, 5 or 6 grammes of isinglass, or fish-glue; dilute this with one deciliter of white wine or of diluted alcohol. Treat the mixture with water till the volume amounts to one liter. Thus prepared, if preserved in a closed bottle, the liquor will remain unaltered for 15 or 20 days, according to the temperature, but it should not be used after becoming strongly acid.

Sub-acetate of lead, which on some accounts (especially for decolorizing) is superior to fish-glue, may be prepared "by digesting 7 parts of litharge with 6 of sugar of lead, and 30 of water, till the oxyd which is not dissolved, has become white."

When *bone-black* is used, its volume had best be about one-third the volume of the liquid to be decolorized, and should be moistened with the liquid before being introduced into the *filter-*

ing tube, as this greatly facilitates a speedy filtration. The same bone-black may be used several times, if care be taken to rinse and dry it after each operation. It has been found also, that its qualities may be in a great measure restored by *burning* anew.

Analysis of Canes.—From M. Clerget's memoir before mentioned, I translate, in *substance*, the following: weigh 200 grammes of the cut cane, and extract the juice therefrom by means of the small *special press*, endeavoring to make the pressure as near that exerted by the common sugar presses as possible, in order that the juice may be a fair representative of that usually extracted in the manufactories; from this juice fill the graduated matrass to the mark indicating a capacity of 100 c. c.; to this add 10 c. c. of the defecating agent as in the analysis of sugar and molasses; filter and introduce it into the tube of observation 22 centim. long: take the *degrees* of variation, which multiply by 164·71 and divide the quotient by 100 and you will have the number of grammes of *sugar* contained in a liter of the juice; the calculation may be dispensed with by referring to the number expressing degrees of deviation in the column of the table marked A, and seeking the corresponding ones of the column marked B, which will give the number of grammes per liter contained in the juice.

If now, by means of a very delicate areometer graduated to the 10th of a degree, we take the density of the liquid, we may infer from a very easy comparison between this density, the saccharimetric title of the juice and the weight of the pressed cane, the actual per cent. of the real sugar contained in the juice to the weight of the original cane: for example, a specimen of 200 grammes of Tahiti cane cultivated in the Antilles was submitted to the action of the small *presse d'essai*, and left a pulp weighing 48 grammes; it consequently produced 152 grammes of juice, of which the density was found to be 108°·5; this juice observed by means of the saccharimeter gave a deviation to the right of 124°; multiplying this number by 164·71 and dividing the product by 100, the quantity of sugar per liter was found to be 204 gr. 24 c., which is the *title* which we also find in the column B, opposite 124° in the column A. Then we have 1085 (weight of a litre of the juice) : 204·24 (weight of the sugar per litre) :: 1 : 0·1882 (the per cent. of the sugar compared to the juice): —and 0·1882 multiplied by 152 we obtain the total quantity of the sugar extracted by simple pressure from the 200 grs. of the cane, that is, 28 gr. 60 c., or 14·30 per cent. of the weight of the cane.

In the analysis of fresh cane juice, it is not usually necessary to perform the operation of inversion—a process which must not be omitted in the examination of molasses and impure brown sugars.

General Remarks.—Professor McCulloh, in his Report to the government, gives 52 per cent. as the average amount of crystallizable sugar contained in West India and Louisiana molasses examined by him. Biot and Soubeiran place the average of their analyses of molasses as low as 40 p. c.; while Ventzke estimates the same at 60 p. c. Much may be attributed to the different circumstances, &c. under which the analyses were made. McCulloh asserts that a saturated solution at 212° Fah., will contain 80 p. c. of cane sugar, 50 of which will crystallize.

The matter has excited considerable interest on the part of the government from the fact that it has been said, that nearly pure *syrups* have been imported by refiners under the name of molasses; and that the resulting refined sugars have been exported under the privilege of the *drawback*. These syrups (*sirops de batterie*) contain, according to McCulloh, 60 p. c. of cane sugar, and may be so disguised as to render it difficult to distinguish them from molasses.

I examined with the instrument before mentioned, several samples of molasses imported from the West Indies, which Dr. E. H. Barton, Inspector of drugs and chemicals, brought from the custom house, with the following results:

Sample A = 50°·6. Right-handed polarization previous to inversion.
= 15°· (at temp. 30° C.) Left-handed " after "
Consequent title, 51 per cent.

Sample B = 44°· R. polarization previous to inversion.
10°· L. " (at temp. 28°) after inversion.
Consequent title, 42 per cent.

Sample C = 46°·2. R. P.
24°· L. P. (at temp. 30°.)
Consequent title, 54·5 per cent.

Sample D = 62°·7. R. P.
20°· L. P. (at temp. 30°.)
Consequent title, 64 per cent.

Sample E = 51°·7. R. P.
20°· L. P. (at temp. 30°.)
Consequent title, 53 per cent.

Sample F = 49°·5. R. P.
10°· L. P. (at temp. 26°.)
Consequent title, 45 per cent.

It has been inferred from experiments by Henry and others, that *cane sugar* is the primary secretion of the plant, and that the grape sugar and uncrystallizable sugar contained in molasses is the result of fermentation, decomposition consequent on ill-management in the manufactories. The former, or cane sugar proper, is termed by Dr. Cartwright the *worm-destroying* sugar, while the latter he terms *worm-producing;* having reference to their medicinal properties.

McCulloh gives 18 per cent. as the proportional amount of cane sugar which he obtained by an analysis of the ripe cane juice, but remarks that it is probable that 21 per cent., as obtained by Péligot and Casaseca, may be the usual or average proportion, since his analysis was made of a particular and unfavorable specimen.

He gives the following as the result of his *comparative analysis of the three varieties of cane:*

	Tahiti.	Creole.	Ribbon.
Water, - -	68·20	68·76	71·45
Solid matter, -	31·80	31·24	28·55
	100·00	100·00	100·00

The proportional yield of sugar from the same he rates respectively at 67·884, 62·918 and 63·68.

In using the saccharimeter of M. Soleil, (or indeed any depending on polarization,) some difficulty may be experienced in properly decolorizing the liquor, which must be quite clear and *transparent* in order to admit of accurate observation. Good bone-black at times is very essential. But when once in proper order, there can be no doubt as to the general accuracy of its saccharimetric determinations.

"The programme of a *prize* offered by the Société d'Encouragement called for a process which should determine, *within two per* cent., the richness of saccharine substances. The process of M. Soleil is much more exact."

ART. XXI.—*Observations on some Mounds on the Tensaw River;* by A. BIGELOW, Wesleyan Institute, Newark, N. J.

DURING a two years residence near Hall's Landing on the Tensaw river, I heard frequent reports of some mounds upon it, about twelve miles to the north, and was induced to visit them at two different times. The first impressions more than realized my expectations, and the examination was one of interest.

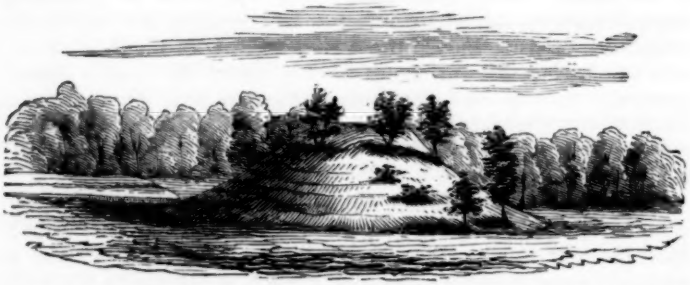
About twenty miles north of Mobile, the Tensaw separates from the Mobile river, running to the east by a very tortuous course as far as Stockton, then to the south, emptying into the east side of Mobile bay. Between these two rivers is enclosed a tract of land, twenty miles long and about seven wide, consisting of marsh and swamp land. Much of it is impassable; some of it quakes and sinks beneath the tread, and is covered with tall grass and aquatic plants; the larger portion supports heavy forests, and is called swamp land. Only small portions of the whole tract are dry even in dry weather, or elevated above the spring floods.

North of the Tensaw, land of a similar character extends for ten miles. The tract between the two rivers is intersected by several creeks and rivers; Middle river, which is wide and deep, flows out of the Tensaw soon after the latter leaves the Mobile, and running southeast, empties again into the Tensaw; thus cutting off a triangular portion from the northeast corner of the tract. Again, Bottle creek leaves the Tensaw not far to the east of Middle river, and running south or west of south, empties into Middle river. In this latter triangular piece, are the mounds. This area is also intersected by the Dominique creek, which runs near to the west side of the mound field, and with which the mounds are connected by a series of small mounds now concealed by the forest. Along with these creeks and rivers are numerous lakes or lagoons, which are affected by the tides, and contain an abundance of fish; indeed the waters teem with them, to an extent which surprises one accustomed to throw the line in clearer streams. Among the inhabitants of these waters, the alligator is not the least abundant, and in a young state, it is yet used occasionally for food, as it appears to have been by the former dwellers upon these banks.

On the west side of Bottle creek, where it leaves the Tensaw, is probably the most elevated portion of the land above described. Here the first inhabitants found sufficient room and material to construct these mounds; and the French a plantation ready for seed. This locality was early settled, and has been cultivated ever since, receiving from the yearly overflow an addition to its fertility. The Gnathodon beds described by Rev. S. C. Hale in this Journal for March, 1851, occur frequently around the head of the bay, but I know of none on Bottle creek; and indeed the Gnathodon shell is but sparsely intermixed in any of the mounds. As low down as within ten miles of the bay, I have seen mounds raised on the banks of existing creeks and near the beds of former ones, with few shells intermixed with the earth. In such cases they look like small portions of levees, elevated just above the high floods. They contain no perceptible relics of former life; and appear to me to have been thrown up, as places of security against high water, by some former people, if not for constant use, at least for a summer residence, for the convenience of obtaining food. To a people unaccustomed or unwilling to till the soil, there existed an unfailing source of food, of a kind which is even now much used by the creoles and negroes living there. The abundance of food and the facility of obtaining it, the convenience of communication by the various creeks, isolation from disturbing tribes, healthiness of the locality,—for the French even went from Mobile to their swamp plantations in summer,—and the mildness of the winter, would induce a tribe to make this region their permanent abode. There is nothing to disprove such a supposition,

except the danger and inconvenience of the floods. Against these the mounds are a security; and, in one case a raised ridge is now used as the site of some buildings. On the Gnathodon beds and the mounds hereafter to be described, relics are often found, the most important of which are images. One bust of a person was discovered near the bay, which very strikingly exhibits the Indian features, and also considerable skill on the part of the sculptor; for these images appear to have been first moulded, and then cut out by some edged instrument. I would here remark that the floods occur at irregular times, usually from February to May, but often in June and July, and occasionally in August.

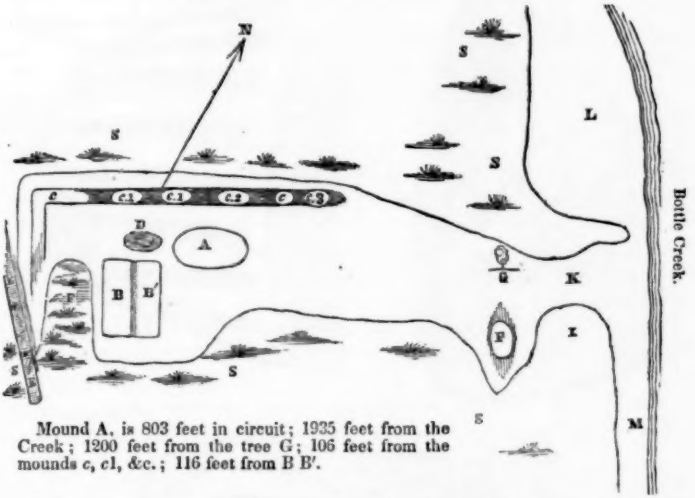
1.



The plantation before spoken of, lies on the Tensaw and Bottle creek, and has a crescent shape; at its southern extremity the eye is attracted through an opening in the forest, by an elevated mound nearly in the center of a large field, the appearance of which as thus seen, is represented in figure 1. This mound is now oval, but has the appearance of having been somewhat rectangular when built. It is a striking object in the landscape, both from its size and elevation. It has a wide base and gradually tapers to the summit, which is 104 feet long by 46 feet wide and elevated about 49 feet above the river at mean tide. The mound stands on ground a little below the surface of the river banks; its sides are covered with trees 40 feet high, and with shrubs and a few palmetto bushes. It has been frequently cultivated in corn, and as its sides have been worked with the plough and hoe, as well as furrowed and washed with rains, we may suppose, that it has been thereby changed in figure and elevation. Near to this is a large rectangular mound of small elevation, one-half its breadth, about five feet higher than the other, and about six feet above high water. On the north and west side of these is a series of low mounds, so connected as to form a ridge of raised earth, extending along one side of a rectangle and part of another till it ends near the swamp. The diameters of the high mound lie in the same directions with the sides of the other mounds; and the

whole arrangement is so regular and nearly rectangular, as to induce one to suppose it laid out by a compass. But I think it to have been done by the eye, according to the position of the ground and river. Its position as respects the compass on the north side is E. by N. E., but it is parallel with the river and general direction of the sides of the field. The entrance looks directly upon the large mound and fronts the whole arrangement. A swamp covered with forests surrounds the whole except the entrance from the river.

2.—Plan of the mounds and field.

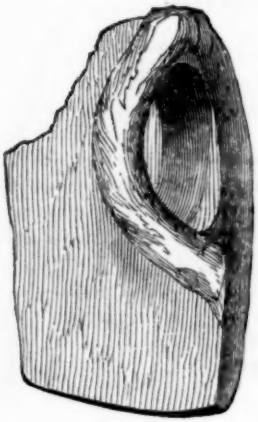


Mound A, is 803 feet in circuit; 1935 feet from the Creek; 1200 feet from the tree G; 106 feet from the mounds *c*, *c*1, &c.; 116 feet from B B'.

For a more particular description the reader is referred to fig. 2. Bottle Creek is represented on the east side; L is a part of the plantation extending to the Tensaw; S S, the swamp which surrounds the whole; K, the entrance to the mound field. On the left is a small mound F, in which were found the bones of an Indian, together with a large collection of beads and other articles usually attending an Indian interment. The beads are globular, three-quarters of an inch in diameter, having a large hole for the string; they are of glass, translucent, and of a bluish color. *c*, *c*1, *c*2, and *c*3, form the portion of a rectangle outside of the larger mounds: *c*3, and the one next to it are much used now for stacking hay to prevent injury by the floods; the others are not quite so high. On *c*1 and *c*2 many images, beads, and pieces of copper have been found, having been turned up by the plough. Upon *c*2 I found an old fire-hearth a short distance below the surface, and beside it the bones of various animals now existing there. Those of the alligator were most abundant. B B′ is the

large rectangular mound; B is about five feet higher than the part B′; it is 344 feet long by 250 wide. I think, from its situation and appearance that the builders designed to bring up the whole to the same elevation, so as to have more room and greater security. Upon this are found great quantities of broken crockery, which evince considerable skill in modelling and finishing. Some of the ware must have been very large, and all of it is covered on the inside and outside with a thin coat of a

3.



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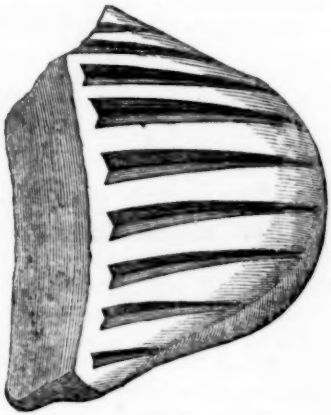

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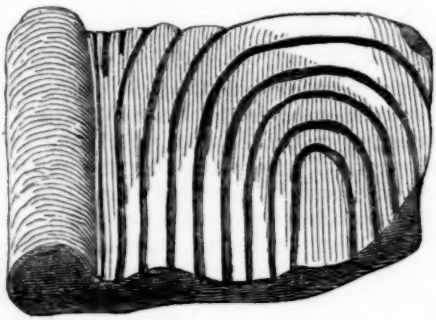

finer quality, which answers the purpose of glazing. Some of the fragments have ears so similar to those used on our iron and eathenware as to induce the belief that the later Indian workers of this ware copied from those on the utensils of the Spaniards when among them. One of these forms, represented in fig. 3, is suitable for receiving a bail; fig. 4 is attached to the side of the upper edge, for conveniently lifting and carrying by the

hands; the upper surface is ornamented with parallel grooves. Nearly all the fragments are ornamented with rude devices, cut in the outercoating by a sharp point. One of these devices is represented in fig. 5, and also the rim of the vessel is shown upon the same fragment. The ware is made of clay of different qualities, and comminuted shells; and is of different shades from a light gray to a black. Their images were made of a purer clay, having a light gray color after baking, but were evidently worked with some tool to the proper form before baking. The image of a man in a sitting posture and so constructed as to form a pipe, the smoke issuing by small holes from the mouth and nose, was found here.

D, in fig. 2, is an excavation of some depth, containing water in which some trees are now growing. It appears by its position, to have been designed as a water hole, or well. It is also an excavation from which material was probably taken for the mound B. A is the large mound occupying the center and overlooking all. E E is a ditch beginning a little south of the mound B B′ and extending northwest nearly to Dominique creek. It contains water and trees, being in the edge of the swamp, and has the appearance of an ancient canal. It is sufficiently long to have afforded nearly all the material for the mounds, and may have been used as a way of approach from the northwest. As before remarked, this system of mounds continues across this ditch towards middle river. I will here state that in digging into these mounds I found an entire absence of stratification, but a mingling of small masses of mud and loam as if promiscuously thrown together. Very few shells are on them or beneath the surface; I found a few Gnathodon and oyster shells.

The trees in the surrounding swamp are comparatively young, and there is no appearance of a former growth. The newer part of this alluvial tract is an open marsh, sinking under the feet, and there is every reason to suppose that this was the character of the whole region when these mounds were built. In that case, a view of a wide region could be had from the high mound, and every approach observed. If the forest then existed, I do not see how the ditch E E could have been excavated with rude tools. It also seems to me that the mounds could not have been built at a remote period, as we may believe that it is not very long since the ground became tenable for such a purpose. Hence towards the head of the bay on this alluvial tract no mounds of note are observable between the rivers, but in the hammock, a higher and firmer land on the east side of the Tensaw five miles above the bay, are some large rectangular mounds, and also some ridges extending from a creek to the river. These show greater age, since very large trees are growing upon them. Their height is not over five or six feet.

These facts, the temptation to a savage people to dwell in the midst of so much food, the necessity of protection against the floods, and the absence so far of great antiquity, lead me to attribute these works to some tribe of the present race of Indians. One examination remains to determine this matter in my opinion, that is, a section cut through the mound A. If no evidences can be found within it of a more ancient people, then the conclusion to which I have come must seem reasonable. I cannot, however, see why our aboriginal Indians should construct so high a mound as A, unless for defense in case of attack. I was told by the negroes who worked the mound when planted, that they had found the stumps of an old stockade. It may easily be conceived that it was a stronghold and a lookout over the then open marsh. It is supposed that the first engagement which De Soto had with the Alabama Indians, was at Choctaw Bluffs, and that thence he led his army across the ford of the Tensaw at this plantation, and from this place passed on westward across the Mobile; and that at no other point could such a passage have been made. Many Spanish relics have been found, such as carbine barrels, rings of brass, pieces of copper ornaments, and swords. One of the latter was nearly entire, having on one side of the hilt an embossed likeness of Ferdinand and on the other of Isabella. The Tensaw Indians at one time probably occupied these regions, but at an early day left for the west, and till the close of the war of 1812, the Creeks claimed all east of the Tensaw river as their hunting ground. These tribes, within the memory of the present inhabitants of Baldwin county, used earthern vessels similar to those above described, for culinary and other purposes.

The localities described above are not the only ones where proofs of former occupation are found. From near Stockton a wide and high road is traced into the swamp nearly in the direction of the mounds we have been describing, covered with large trees. While we wonder at the taste which led any people to locate themselves on these marshes, we wonder equally at the evidences of a rather numerous population, which are presented as we paddle in a light pirogue along the creeks and into the lakes of the region.

Art. XXII.—*On the Phosphorescence of some Marine Invertebrata;* by M. A. De Quatrefages.*

I. *Historical review of the subject.*

1. *Causes of phosphorescence.*—It is well known that the waters of the sea, in some latitudes and under certain circumstances, are phosphorescent, producing a light more or less brilliant. This remarkable phenomenon has always attracted the attention of travellers, and various have been the explanations they have offered. Without going here into useless detail, we will first mention those hypotheses which are now completely set aside, before dwelling on better founded opinions.

Ancient navigators seem to have indicated a resemblance between the light produced on the surface of the water and that which is due to atmospheric phenomena, by designating the former "meteors of the sea." Something of this idea is evident even in the writings of learned men, who endeavored to explain this phosphorescence solely by physical or chemical causes. Thus Nollet could see in it only a simple modification of electrical phenomena. Bajon, in his memoirs on the History of Cayenne, regards this light as due to the electricity of the waves, developed by the force of opposing currents or by the prows of vessels. Other authors have attributed it to phosphoric fires, to the burning of bubbles of hydrogen which rise to the surface to explode, &c. &c. The opinion published by Tingry is of a similar nature. This philosopher regards the phosphorescence of the sea as analogous to that which certain bodies, the diamond in particular, present, after having been a while exposed to the sun. Without entirely setting aside the agency of animals, he attributes the greater part of the phenomenon to a sort of previous imbibition of the sun's rays, which are thrown out again during the night. He thus explains entirely by physical causes the remarkable intensity of this phosphorescence in tropical seas.†

A more rational if not a more correct explanation, at least for many cases, is that which attributes the phosphorescence of the sea to the decomposition of fishes and other marine animals. This opinion was adopted by Commerson in his manuscripts which are deposited in the Library of the Museum.

A passage very much to the point is quoted by Lesson from one of his manuscripts.‡ "Phosphorescence is owing to a general cause, that of the decomposition of animal substances, espe-

* From the Annales des Sci. Naturelles, vol. liv, 3d series.

† De la phosphorescence des corps, et particulièrement de celle des eaux de la mer (Journal de Physique, t. xlvii).

‡ Dict. des Sc. Nat., article, Phosphorescence.

cially of whales and seals, which abound in oily matters." Bory de St. Vincent, Oken, and others have adopted the same view. There is certainly great appearance of probability in this explanation, it is sustained by well known facts and sufficiently accounts for certain circumstances of the phenomenon. Still in many cases it is scarcely better founded than the preceding. The same appears to have been the opinion of Newland, and of those who like him have attributed phosphorescence to the spawn of fishes.

But, since the beginning of the last century, careful observations have been made; and various observers have found that a great number of sea animals have the property of directly emitting this light. Since 1805, Viviani, professor of natural history at Genoa, has discovered in the neighborhood of that city, and described in a work on the subject, fourteen species of phosphorescent animals.*

Many travellers have noticed the phosphorescent properties of the Medusæ. Spallanzani, by diffusing in milk the mucus from their bodies, rendered the liquid luminous.† Vianelli attributed the phosphorescence of the sea to a Nereis; Shaw, to certain flexible zoophytes, &c.

French naturalists have not been behind in this movement. In 1764, Rigaut discovered and described in an unmistakable manner the Noctiluca of Suriray; it is to them that he attributes the phosphorescence of the British Channel and Atlantic Ocean. The Abbé Dicquemare, by researches in the harbor of Havre confirmed the first results, which, forgotten for a time, were again corroborated by the labors of Suriray at the same locality. The learned hydrographical engineer, M. de Tessan, rediscovered the Noctilucæ, or animals very similar, in the seas of the Cape of Good Hope, at False Bay.‡ M. Rang mentions their presence on the coast of Algiers.§ More recently M. Verhaeghe has been led by his investigations at Ostend‖ to the same conclusions as Dicquemare and Suriray.

The assertion of Rigaut was manifestly exaggerated; the Noctilucæ are not alone in producing this phenomenon. The luminous properties of various Medusæ have been established beyond doubt by the testimony of Peron, Macartney, Tilesius, Banks, Forskal, Humboldt, Ehrenberg, Rathke, etc. Peron and Lesueur, Humboldt and others after them, have described with en-

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* Phosphorescencia maris quatuordecim lucescentium animalculorum novis speciebus illustrata. Genuæ, 1807. † Voyage en Sicile.

‡ Comptes Rendus de l'Académie des Sciences, 1840. Rapport fait par M. Arago.

§ Cited from Gervais, by M. Van Beneden.

‖ Report of M. Van Beneden on the menoir of Dr. Verhaeghe, emitled, Recherches sur la cause de la phosphorescence de la mer dans les parages d'Ostende (Bulletin de l'Académie royale de Belgique, t. xiii, Part ii, p. 3, 1846.)

thusiasm the magnificent spectacle presented by shoals of Pyrosomas, which in the dark look like streams of fused metal. Henderson ascribed the light of the gulf of Guinea principally to the Scyllari and to Salpas.* Certain Acalephs, Mollusca, Crustacea, Annelids, Rotatoria, Lumbrici, Turbellariæ, Echinoderms, Zoophytes and Infusoria have been successively pointed out as capable of phosphorescence; and if we do not here go into more detail on this point, it is because the subject has been so fully treated by Ehrenberg. In the work which the illustrious Secretary of the Berlin Academy has devoted to the phosphorescence of the sea, he has enumerated 450 authors who have treated more or less fully of the production of light by organized beings; and to this memoir we refer those readers who are curious to understand thoroughly the history of the question.† We annex a table, cited almost entire from M. Van Beneden, in which are enumerated the various species of invertebrate animals whose phosphorescence has been established.

INSECTS.

G. Lampyris.—L. noctiluca, L. splendidula, L. italica, L. ignita, L. phosphorea, L. nitidula, L. lucida, L. hemiptera, L. japonica.
G. Elater.—E. noctilucus, E. ignitus, E. phosphoreus, E. lampadion, E. retrospiciens, E. lucidulus, E. lucernula, E. speculator, E. janus, E. pyrophanus, E. luminosus, E. lucens, E. extinctus, E. cucujus, E. lucifer.
G. Buprestis.—B. ocellata.
G. Chiroscelis.—C. bifenestrata.
G. Scarabeus.—S. phosphoricus.
G. Pausus.—P. sphærocerus.
G. Fulgor.—F. laternaria, F. serrata, F. pyrrhorhynchus, F. candelaria.
G. Pyralis.—P. minor.
G. Achita.—A. gryllotalpa ?

MYRIAPODA.

G. Scolopendra.—S. electrica, S. phosphorea, S. morsitans.
G. Julus.

CRUSTACEA.

G. Carcinium.—C. opalinum.
G. Erythrocephalus.—E. macropthalmus.
G. Scyllarus.—Espèce indéterminée.
G. Gammarus.—G. pulex.
G. Cyclops.—C. brevicornis.
G. Oniscus.—O. fulgens.

ANNELIDA.

G. Nereis.—N. mucronata, N. noctiluca, N. phosphorans.
G. Syllis.—S. fulgurans.
G. Photocharis.—P. cirrhigera.
G. Polynoe.—P. fulgurans.
G. Chætopterus.—C. pergamentaceus.
G. Lumbricus.—L. phosphoreus.
G. Planaria.—P. retusa.

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* Cited by M. Van Beneden.

† Das Leuchten des Meeres (Abhandl. der Kœnigl. Akademie der Wiss. zu Berlin, 1834).

MOLLUSCA.

G. Helix.—H. noctiluca.
G. Pholas.—P. dactylus.
G. Pyrosoma.—P. atlanticum, P. giganteum.
G. Phallusia.—P. intestinalis.
G. Salpa.—S. zonaria, S. Tilesii.

ECHINODERMATA.

G. Asterias?
G. Ophiura.—O. telactes, O. phosphorea.

ACALEPHA.

G. Pelagia.—P. phosphorea, P. noctiluca.
G. Oceania.—O. Blumenbachii, O. pileata, O. hemispherica (Thaumantias), O. lenticula, O. microscopica, O. scintillans.
G. Beroe.—B. fulgens, B. rufescens.
G. Cydipe.—C. pileus.
G. Mnemia.—M. Norwegica.

POLYPI.

G. Pennatula.—P. phosphorea, P. grisea, P. rubra, P. argentea.
G. Veretillum?
G. Gorgonia?
G. Sertularia?
G. Alcyonia?

INFUSORIA.

G. Ceratium.—C. tripos, C. fusus.
G. Peridinium.—P. Michaelis, P. acuminatum, P. furca.
G. Prorocentrum.—P. micans.
G. Stentor?
G. Synchæta.—S. baltica.
G. Noctiluca.—N. miliaris.

We believe that the above list is far from complete, at least as regards marine animals. Our own observations enable us to add at least two species of Polynöe, one species of Syllis, some species of allied genera, and one or two of Ophiura.*

II. *On the mode of producing light by Marine Invertebrata.*

Almost all researches undertaken to discover the manner of producing light in animals, have been made on insects, especially the Lampyri and Elaters. Spallanzani, Burmeister, but above all, Macaire,† have published results apparently decisive. These

* In the above list of phosphorescent Crustacea, *Oniscus fulgens* is a *Sapphirina*; and the *Carcinium* probably belongs to the same genus (see this Journ., [2], ix, 133). *Regulus*, *Euphausia* and *Cypridina* are other phosphorescent genera, as observed by the writer; and also Lucifer according to Thompson, (Zool. Researches, p. 58,) and Thysanopoda, *Edw.* Cypridina is evidently the genus of the species referred to by Reville as observed to be phosphorescent on a voyage to India, (Mem. de l'Acad. des Sci., Savans Etrangers, iii, 267, and Thompson's Zool. Res., p. 41.)

Scyllarus must be incorrectly added to the list, as there are no oceanic species of the genus. The error is moreover evident from the fact that the reference of the phosphorescent Crustacea to this genus, was made before the species were well understood. Captain Tuckey who states the facts, in his voyage to the Congo has the words, "with little Crustaceous animals of the Scyllarus Genus (attached to them [Salpæ]),"—evidently inconsistent with the genus Scyllarus, which includes large species of very different habits. The term was probably meant for *Squilla*, and the species may have been Schizopods of the family Euphausidæ.—J. D. D.

† Journal de Physique, t. xciii.

experiments undertaken and varied by Matteucci,* with all the precautions furnished by experimental science at the present day, leave, we think, no room for doubt. In the insect which he examined, the light was produced by an actual slow combustion analogous to that of phosphorus exposed to the air. This light is extinguished in a vacuum and in the irrespirable gases; it reappears by contact with atmospheric air; it is sensibly brightened in pure oxygen; it continues in animals after they are dead, or even cut to pieces. The particular substance from which it emanates may be isolated, and may leave upon the fingers or the dissecting instrument a luminous streak which disappears only on drying; a little dampness even, in certain cases, is sufficient to restore the phosphorescence; finally, the production of this light is accompanied in the living animal, as well as in its dead carcass, by the escape of carbonic acid. Everything concurs then to show that the phosphorescence of insects, and probably of all aerial animals, is owing to a peculiar secretion, whose substance combining slowly with oxygen produces light.

But can this explanation of phosphorescence be applied to invertebrated animals living in water? Such questions immediately arise but yet have been overlooked by most naturalists. The greater part of the observers from whose works we have cited have been satisfied with knowing that animals produced the phosphorescence of the sea; some have gone a little farther and have attributed this phenomenon to the secretion of a luminous liquid. This opinion appears generally adopted, and traces of it may be seen even in the writings of some naturalists who have not formally stated it. The experiments of Spallanzani and the observations of many travellers seem fully to confirm this view, which is evidently correct in some cases. Dugés, for instance, has decidedly adopted it, and has implied a resemblance between the phosphorescence of the Medusæ and Annelids, &c., and that of the Elaters and Lampyrides.†

A very different opinion has been set forth by M. Gilbert, an officer of the corps of naval engineers, who without being aware of the investigations of others on this subject, had seen the Noctilucæ and describes them rather coarsely but in a manner easily recognized. He explains the production of light in these animals by the development of electricity from the surface of their bodies, a development brought out by the action of the waves.‡ This explanation is evidently untenable even in a merely physical point of view.

Lesson appears to us one of the first, if not the first, who has seen in phosphorescence a phenomenon distinct from the physico-

* Leçon sur les phénomènes physiques des corps vivants, 8e leçon.
† Traité de physiologie comparée. t. ii. Montpellier, 1838.
‡ Annales maritimes, 1817.

chemical actions which take place in our laboratories, but without explaining himself very fully on this subject. This naturalist regards phosphorescence as due to Crustacea belonging to different genera; he allows that the seat of this light, emitted on irritation or at the time of procreation, resides in glands placed in a variable number on the sides of the thorax. He adds: "this light should be regarded, as a fact established by investigation, as a modification of the laws of life, and as different from the simple sparkling light resulting from the decomposition of animal substances.*

Carus, losing sight of the philosophy which prevails in his works, adopts the opinion that this phenomenon is a property of *primary animal matter*, which is nothing else than the nervous substance and which representing the solar element in the animal, necessarily appears luminous to the planetary element.† He then, as well as Oken, from whom he cites the passage, "regards the jelly of Zoophytes, Medusæ, &c., as the nervous substance in its lowest stage, from which the other substances embraced within it have not been isolated."

M. Bérard, cited by Duges,‡ regards the phosphorescence of animals as due to a kind of luminous imbibition, or purely vital effect, analogous to those which result in different bodies, from the action of heat, electricity, light, &c.

Dr. Coldstream published in Todd's Encyclopedia a very interesting article on phosphorescence.§ After having examined the nature of animal light, the natural or artificial circumstances which influence its appearance or intensity, the points of body in different animals from which it is produced, he sums up all that we have learned from different authors of the phosphorescent organs, and the different theories proposed to explain these phenomena. We quote from this English author some passages from this part of his work.

According to Beccaria, Meyen, &c., the phosphorescence of animals is owing to what they absorb from the rays of the sun, which they throw out again in the dark.

Spallanzani regards phosphorescence as a kind of combustion sustained by the oxygen of the air.

According to Brugnatelli, the light is taken in with the food, and disengaged by particular organs.

Macaire considers the phosphorescent matter as composed of phosphorus and albumen. The variations of intensity apparent in the light arise more or less from the coagulation of the albu-

* Dict. des Sc. Natur., 1826, article Phosphorescence.
† Traité élémentaire d'anatomie comparée, traduit par Jourdan, t. i.
‡ Traité de physiologie comparée, t. ii.
§ The Cyclopedia of anatomy and physiology, Part xxii, article Animal luminousness, 1841.

men, a coagulation which is increased or diminished at the will of the animal, and permits a more or less rapid combustion.

Tiedemann, Darwin, H. Davy, Heinrich, Treviranus, Burmeister, &c., believe in the secretion of a liquid containing phosphorus, and in the combustion owing to the air introduced by respiration.

Macartney and Todd regard phosphorescence as due to the nervous fluid concentrated and modified by certain organs, so as to appear under the form of light.

The author next proposes his own theory founded on a sort of fusion between the two preceding. With Macartney, he admits that phosphorescence is due to an imponderable agent, and compares it to the production of electricity by certain fishes. But considering the well known fact of the luminous traces that certain animals leave behind them, he supposes that phosphorus or an analogous substance may very well enter into the composition of the organs which produce the light.

It is plain that Dr. Coldstream, in common with all the authors whom we have cited, believed that phosphorescence should be attributed to but one cause.

This error M. Becquerel* has avoided. After having shown that in the Lampyris and other insects, phosphorescence is the result of a chemical action at the control of the animal, M. Becquerel relates the observations of Ehrenberg, and admits with him that in certain inferior animals the production of light is owing to a disengagement of electricity. Moreover, he recalls the observations of MM. Quoy and Gaimard, who had seen under the equator, near the island of Rawak, small zoophytes, which while swimming rapidly, drew after them luminous trains. Finally, M. Becquerel, resting on this fact, and on his own observations made in company with M. Breschet, at Venice, in the waters of the Brenta, allows that the phosphorescence of the sea may be owing to an organic substance intimately combined or mingled with the water, analogous to that which covers the herring and other fish when they are phosphorescent.

Doctor Coldstream seems not to have known of two memoirs which appeared in Germany, about the same time, and which we have reserved for the close of this history, on account of their peculiar interest.

The first of these works is that of M. Ehrenberg,† and it is incontestibly the most complete which has been published on this subject. To all the facts made known by his predecessors, the author adds the result of his own investigations in many seas. At Alexandria he established beyond doubt the fact that the

* Traité de physique comparée, dans ses rapports avec la chimie et les sciences naturelles, t. ii, 1844.

† Loc. Cit.

Spongodium vermiculare, as also other Algæ regarded as phosphorescent, owe this appearance only to the luminous animalcules adhering to their surface. He describes a new species of Polynöe (*P. fulgurans*) found by him in the Baltic, that apparently plays an important part in the phosphorescence of that sea, which also owes its luminous properties to different infusoria. At Christiana and at Helgoland, Ehrenberg observed this phenomenon in many species of Medusæ; at the last locality he met with the *Noctiluca miliaris*, which he calls Mammaria. Ehrenberg describes also the very remarkable mode of phosphorescence which appeared in a Nereid, the *Photocharis cirrhigera*. In that Annelid, the light proceeds from two thick and fleshy cirri belonging to the dorsal branch of the feet. The author observed sparks, at first isolated, invade the cirri by degrees, until they became luminous in their whole extent; then the phosphorescence spread through the whole back, until the animal looked like a thread of burning sulphur. The mucus secreted by the Photocharis left on the fingers a luminous trace. In the *Polynöe fulgurans*, Ehrenberg regards two large rough bodies, resembling ovaries, as charged with producing the light. In the *Cydipe pileus*, and in the *Oceania pileata*, he found that the light starts from the centre, that is, in the neighborhood of the reproducing organs. In the *Oceania hemispherica*, a species whose diameter is more than an inch, Ehrenberg saw the sparks from a chaplet around the border; these correspond to the large cirri or to the organs alternating with them.

Ehrenberg sums up in the following manner the important results of his labors:

1st. The phosphorescence of the sea appears to be owing solely to organized beings.

2d. A very great number of organic and inorganic bodies shine in the water, and out of the water in different ways.

3d. There is also a light from organized bodies which is probably owing to vital action.

4th. The active organic light shows itself frequently under the form of a simple flash, repeated from time to time, spontaneous or provoked. Often also it appears under the form of repeated sparks, following each other in quick successions, under the influence of the will, and very similar to electric sparks. Often, but not always, there is formed by this production of sparks, a mucilaginous humor, gelatinous or aqueous, which is diffused around in great abundance, and is evidently placed in a secondary or passive state of phosphorescence, which continues a long time without requiring any new influence from the organic being, and even lasts after that has been divided or destroyed.

A light which to the naked eye appears uniform and tranquil, shows itself scintillating under the microscope.

5th. The viscous humor which envelops and penetrates the ovaries seems to be especially susceptible of acquiring this communicated light, which is constantly reinforced by friction, and reappears even when it seems to have ceased.

May not the light emitted by living fishes, by Actinias, and by many other animals covered with mucosity, be sometimes merely communicated?

6th. The relations which exist between the production of light and the sexual functions are evident in the Coleoptera, although the connection of the small luminous sacs with the reproductive organs may remain concealed. With many marine hermaphrodite animals, phosphorescence appears to be a means of defence and protection, analogous to those of another kind which exist in the *Brachinus crepitans*, the cuttle fish, the frog, or to the discharges of the torpedo. Whatever it may be, the air and the sea have their phosphorescence.

7th. As yet it is only among the Annelids, and of them only in the Photocharis that a peculiar phosphorescent organ has been discovered; it is external, tufted, frequently giving out light, similar to a thick cirrus, showing a largely cellular structure, and formed within of a mucilaginous substance. The expanded base of the marginal cirri in the Thaumantias (Acalephs) may be regarded as phosphorescent organs, of an unusual kind. The ovaries are more probably luminous, passively and in a secondary manner, although their minuteness and transparency have prevented our ascertaining whether the organs of phosphorescence are placed near them; as for instance in the *Polynöe* and *Pyrosomas*.

8th. The production of light is evidently a vital act very similar to the development of electricity, an act which being completely individual, becomes more feeble and ceases on too frequent repetition, which reappears after a short interval of repose, to the production of which absolute integrity of the organism is not necessary, but which sometimes manifests direct connections only with the nervous system.

The memoir of Meyen is less extended, but it contains some important facts.* The author admits three kinds of phosphorescence. 1. The phenomenon is owing to a mucosity diffused in water. In that case the water seen in the day has a uniform tint of bluish white. It is often observed in tropical ports, but rarely out on the open sea. This mode of phosphorescence may be produced artificially by washing or by crushing certain Molluscs and Acalephs either in sea-water or in fresh. 2. Phosphorescence results from the presence of certain living animals, endowed with a luminous mucus. This continues even after the

* Beitræge zur Zoologie, von F. J. F. Meyen, fünfte Abhandlung. Uber das Leuchten des Meeres (Nov. act. nat. cur., t. xvi, suppl., 1834).

death of the animal; it arises from a superficial oxydation of the mucous coating, and it can be reproduced after it seems extinct by passing the finger over the animal. The animals which owe their luminous property to a secretion are, according to the author, Infusoria, Rotifera, Biphoræ, Medusæ, Astoria, Cuttle fish, Sertulariæ, Pennatulæ, Planariæ, Crustacea, and Annelids. 3. The third cause of phosphorescence is in some animals from the presence of one or more special organs. Of this number are the Pyrosoma, and especially P. Alatantica, whose light of a greenish blue is very brilliant. Each individual carries behind its mouth a soft opaque substance, of a reddish brown color. This body is slightly conical, and under the microscope thirty or forty red points may be seen; it is this substance which produces the light.

III. *Observations.*

It is apparent from the foregoing statements that the great majority of naturalists, whatever explanation they have given of the phosphorescent phenomena, have applied that explanation indiscriminately to all cases. Meyen himself, while admitting three kinds of phosphorescence, nowhere expresses the idea that the production of light arises from causes essentially different.

It is in this point, I believe, that the writings of these learned men are deficient. In a note published in 1843, and inserted in this Journal,* I endeavored to establish a different opinion, and to show, that under the general name of phosphorescence, phenomena essentially distinct have been confounded, and which have really nothing in common but the production of light. We have already shown that such is also the opinion of M. Becquerel. After having reviewed all that my predecessors have written on the subject; after having made new experiments and new observations, I am more than ever persuaded that it is really so. Without speaking of the phosphorescence arising from animal decomposition, nor of that which results from mucus in a state of solution, I believe that light is produced in living animals in two ways:

1st. By the secretion of a peculiar substance exuding either from the entire body, or from a special organ. It is probable that in this first mode of phosphorescence, the light always arises from a slow combustion. The fact is proved as regards insects, but direct experiments are necessary before the same certainty can exist as to marine Invertebrata, Annelids, Molluscs or Radiata.

2d. By a vital action, whence results the production of a pure light independent of all material secretion. I had arrived at this result at the time of the publication of my first note. My ob-

* Note sur un nouveau mode de phosphorescence observè chez quelques Annélides et Ophiures, (Ann. des Sc. Nat., 2e séries, t. xix, p. 185.)

servations accord entirely with those that Ehrenberg made before me; yet doubts have been thrown out on the legitimacy of conclusions which we had both considered warranted by facts furnished by observation alone. I hope that the experiments which form the subject of the latter part of this memoir will reply to all these objections.

When I published my first note, I was informed of Ehrenberg's results only through a conversation with Humboldt. I have since consulted his memoir, and find that on some points we agree entirely, while we differ on others.

With Ehrenberg I had learned to see in the phosphorescence of the Annelids and Ophiura which I have examined, an action essentially vital; but I cannot regard this action as strictly confined, either to the organs or the functions of generation, as the learned naturalist of Berlin considers it. I find, it is true, in reviewing my notes, that one of the Polynöe which best exhibited the phosphorescence was filled with Zoospermes in full maturity, but many other Annelids among those which I have studied were not in that state. Even in admitting that the light may be most brilliant at the period of gestation, I should regard that fact as merely a coincidence arising from the increase of vital energy which is thus very plainly manifested by all these animals. Besides, in the Ophiura, the independence of the light and the generative organs is very evident, since the sparks are seen only along the arms, and the reproductive organs are enclosed in the body, whose walls are very thick.

M. Ehrenberg first made known the fact that the phosphorescence of Annelids, etc., always results from a combination of microscopic sparks. Here my observations accord entirely with his. We have compared these little flashes to those which are produced from a 'tableau fulminant' which has been charged from an electrical machine.

But M. Ehrenberg has described in the Polynöe a special organ for producing this light. Here we differ. In the Polynöe as in the Syllæ and the other little Nereids which have been the subject of my investigations, I have never perceived any peculiar organ from which the light appeared to emanate. The muscles alone, and particularly the muscles of the feet, have appeared to me to present this phenomenon. I have seen moreover, some Syllæ for instance, shine through the whole extent of their bodies; and in this case the comparison to a thread of burning sulphur is striking and just. This is the appearance to the naked eye; but under the magnifying glass, this thread is divided into a double range of luminous points corresponding to the feet.

I am far from denying that certain animals may have organs charged with secreting light as certain fishes possess those for secreting electricity; but up to this time I have never seen that

sparkling light show itself except in the muscles and at the moment of contraction. There may, undoubtedly, exist on this point, reasonable uncertainty with regard to those Annelids whose foot muscles are lodged in the abdomen; but this cannot be true with respect to the Ophiura, and nothing is easier than to prove this even to the unaided vision, as in the latter the phosphorescence appears along the arm and only during movement. Moreover, the details which will be given beyond of the phosphorescence of the Noctilucæ will show plainly, I believe, that these animals have no special organ for producing the light.

Finally, the Photocharis observed by Ehrenberg secreted a liquid which left luminous traces on the objects which came in contact with it. This peculiarity I have also met with in one of my Annelids; but generally in the latter and especially also in the Ophiura, the light was owing entirely to the scintillations and disappeared with them. It is however easy to believe that the modes of phosphorescence which we have admitted may coexist in the same animal.

(*To be continued.*)

ART. XXIII.—*On the question whether Temperature determines the Distribution of Marine Species of Animals in Depth;* by JAMES D. DANA.

IT is a question of much interest, how far temperature influences the range of zoological species in depth. From a survey of the facts relating to coral-zoophytes, the author arrived at the conclusion that this cause is of but secondary importance.* After determining the limiting temperature bounding the coral-reef seas, and ascertaining the distribution of reefs, it was easy to compare this temperature with that of the greatest depths at which the proper reef corals occur. This depth is but 100 feet. Now the limiting temperature, 68°, is reached under the equator at a depth of 500 feet, and under the parallel of 10° at a depth of at least 300 feet. There must therefore be some other cause besides temperature; and this may be amount of pressure, of light, or of atmospheric air dissolved in the waters.

Prof. Forbes has remarked that the deep sea species in the Ægean have a boreal character;† and Lieut. Spratt has ascertained the temperatures at different depths,‡ and shown that the deep sea species are those which have the widest range of distribution, most of them occurring north about the British shores, or

* Exped. Report on Zoophytes, 1846, p. 103; and on Geology, p. 97; this Jour., [2], xii, 180.

† Report on the Ægean Invertebrata, Rep. Brit. Assoc., 1843, 130.

‡ Rep. Brit. Assoc., 1848, 81.

north of France. Yet is it true that the species which occur in deep water in the Ægean are found in shallow waters of like temperature about the more northern coasts? If so, Lieut. Spratt's conclusion, that temperature is the principal influence which governs the distribution of marine fauna in depth as well as in latitudinal distribution, will stand as true. But we believe that facts do not bear out this conclusion. Deep sea species live in deep seas in both regions, with but little difference in the depth to which they extend. They are boreal in character, when of Mediterranean origin, because they are cold water species; and their wide distribution is because of the wide range of temperature for which they are fitted, rather than their fitness to endure a given temperature which they find at considerable depths to the south, and near the surface to the north.

As this point is one of much importance, we have run over the recent tables of dredging, by Prof. E. Forbes, in the Ægean and about the British Islands,* to see how far it is borne out; and we add other results by R. MacAndrew, Esq., at Vigo Bay, Portugal, Gibraltar, Malta and Pantellaria, Algiers and Tunis.†

	North Scotland and Shetlands	S'th England and I. of Man.	Vigo Bay.	Gibraltar.	Ægean.	Malta and Pantellaria.	Algiers and Tunis.
Corbula nucleus,	3–80	5–50	5–25	8–20	7–80	6–50	8; 35
Nevera cuspidata	10–80	50	20	45‡	12–185	....	
Thracia phaseolina,	0–80?	3–30	....	....	7–30	....	
Solen pellucidus,	7–100	5–50	....	40	.....	....	35
Psammobia ferroensis,	3–90	5–50	....	8‡	20–40	....	10
Tellina donacina,	1–80	5–40	....	....	7–45	....	10
Mactra subtruncata,	0–12	0–20?	5–10	....	.....	....	6
Lutraria elliptica,	0–10	0–20	low wat'r	....	.....	....	
Cytherea chione,	....	10–20?	....	8	7–10	6–15	
Venus ovata,	5–100	7–50	8	6–40	29–135	6–40	6–35
Venus fasciata,	5–90	7–50	8	8	27–40	6–50	6–35
Venus verrucosa,	....	0–10	5	6	2–40	6–15	6
Artemis lincta,	0–80	5–50	low wat'r	6	.....	6–15	6–8
Cardium echinatum,	5–100?	5–50	littoral.	....	7–50	....	
Lucina flexuosa,	3–100	5–50	4	....	7–11	....	
Lucina spinifera,	10–100	15–30?	10–12	15–25	4–30	6–40	35
Kellia suborbicularis,	0–90	10–40	8	....	29–45	35–50	
Modiola tulipa,	10–50	5–25	12	10–25	2–50	....	35
Modiola barbata,	....	2–15	....	....	7–95	6–15	6–8
Arca tetragona,	10–60	20–30	8‡	30	20–80	35–50	35
Arca lactea,	....	10–50	....	12–20	0–150	....	6–35
Pectunculus glycimeris,	5–80	5–50	8–12	30	6–24	....	35
Nucula nitida,	5–60	5–30	20–25	12–40	.....	6–15	6–8
Nucula nucleus,	5–100	5–50	5–25	6–20	2–10	6–40	6–35
Lima subauriculata,	4–100	15–30	....	35	15–30	....	35
Pecten similis,	2–80	20–50	20‡	....	27–185	....	35
Pecten maximus,	2–40	10–30	8	4–25	.....	35–50	6–8
Pecten opercularis,	2–100	5–50	8–20	20–40	10–70	....	35
Pecten varius,	3–20	3–30	8	8	7–55	6–15	35
Anomia ephipphium,	0–80	0–50	10	....	20–40	35–50	6–35

* Rep. Brit. Assoc., 1843; and on British Marine Zoology, ibid, 1850, 192.
† Rep. Brit. Assoc., 1850, p. 264. ‡ Not found living at the depth stated.

The great care and thoroughness of Prof. Forbes's researches, and those also of MacAndrew, give peculiar weight to the conclusions. Those species are taken from the tables which are common to these several regions, and with regard to which the observations are free from doubt; and we have confined the list to the *Acephalous Molluscs*, as these appear to be sufficient to test the law under discussion. The depth is given in *fathoms*.

It should be observed, that, to carry out the theory, the species should be confined to *shallower* waters to the north than to the south.

To compare fairly this table, it should be noted that the dredging at the Shetlands, Orkneys, and north of Scotland, was carried to a greater depth than about southern England, fifty fathoms being the limit in the latter region, as the waters are shallow. Making this allowance, we are still struck with the *great depth* to which the species penetrate at the most northern locality, instead of the *small* depth. Out of the 21 species which are here mentioned as occurring in northern Scotland or the Shetlands, and the Ægean, 14 or 15 descend to a *greater* depth in the former than in the latter; and nearly all the species common to the north and south extremities of the British Islands, are reported from the deepest waters at the north. Of the observations made at Vigo Bay, Malta, Pantellaria, Tunis, Algiers and Gibraltar, there is but a single example among the above species of a greater range in depth than occurs in the northernmost locality examined. The dredging in the Mediterranean by McAndrew, was not carried to as great depths; yet even allowing for this, the facts are not a little remarkable.

Now the temperature in the Ægean during the warmer months, according to Lieut. Spratt, is as follows. At the surface 76° to 84°.

10	fathoms,	seldom	below	74°	in	the	summer.
20	"	"	"	68°	"	"	"
35	"	"	"	62°	"	"	"
75	"	"	"	56°	"	"	"
100 to 300	"	"	"	55 to 55½°			"

The temperature of the waters near Southern England in summer is 62°; and near the Shetlands 55° or less. Consequently the surface summer temperature of the British Channel is not found in the Ægean at a less depth than 35 fathoms, and the *surface summer temperature of the Shetlands is the temperature at one to three hundred fathoms in the Ægean;* and still species that range to a depth of 100 fathoms about northern Scotland are found within 30 fathoms of the surface in the Ægean, that is where the summer temperature is 74° or more. Such facts show the hardiness of the species in enduring great ranges in temperature. We must therefore conclude that it is not temperature

alone or mainly which determines the *depth* to which species may live. It exerts an influence, and species fitted for cold waters may be found in the deeper seas where such waters occur. But the limit of descent depends on other influences.

Looking at this table in another way, we see, as recognized by Prof. Forbes, that species which occur at or near the surface in Northern Scotland, are generally met with only at greater depths in the Mediterranean; that is, the minimum depth is less in the former case than the latter. Thus *Corbula nucleus* has for its minimum depth in the Mediterranean six fathoms, and in the northern regions three fathoms. *Psammobia ferroensis* has ten fathoms for the former, and three for the latter. Other examples will be found in the above table, sufficient to illustrate the principle although many exceptions exist. Thus species that have a range of 100 fathoms beyond Scotland may have the same in the Mediterranean, except that in many cases they do not reach as near the surface, where the waters are warm.

The Crustacea of the same seas illustrate this subject in a similar way. But the observations upon them have been made with less thoroughness and we have therefore confined our discussions to Mollusks.

ART. XXIV.—*Reëxamination of American Minerals:* Part 1st. —*Emerylite; Euphyllite; Litchfield Mica; Unionite; Kerolite; Bowenite; Williamsite; Lancasterite; Hydro-magnesite; Magnesite:* by J. LAWRENCE SMITH, M.D., Professor of Chemistry in the University of Virginia, and GEORGE J. BRUSH, Ph. B., Assistant to the Chemical Department.

IN the investigations which will be detailed, we have endeavored to clear up the doubts due to imperfect analyses and descriptions that exist respecting several American minerals. Every care has been taken to procure the best specimens, and our results have been tested by several analyses of each. We are under obligations to several mineralogists of this country who have placed their cabinets at our disposal for this investigation, and among those to whom we are more specially indebted, we take pleasure in mentioning Messrs. L. White Williams and W. W. Jeffries of Westchester, Pa., T. F. Seal of Philadelphia, and Mr. Theo. S. Gold of West Cornwall, Ct.

1. *Emerylite identical with Margarite.*

Emerylite was originally found by one of us on the emery of Asia Minor, and also on the same mineral coming from the Grecian Archipelago, Siberia, and China; it was subsequently

traced by Prof. Silliman, Jr., in connection with the corundum occurring in various parts of this country. Its constant occurrence with emery and corundum (forming one of the minerals of elimination in their formation) suggested the name emerylite as most appropriate, its composition having been found to be different from that of any known mineral.

It was justly considered an interesting species, on account of its accompanying the various forms of corundum wherever observed; and it may be safely said, that no mineral has been proved to be as widely distributed in so short a time after the first announcement of its connection with the emery of Asia Minor, and the suggestion that it might be found with the corundum of other localities.

The analyses which were immediately made of this mineral by different chemists, on specimens coming from various parts of the world, showed a uniformity of composition most remarkable in a micaceous mineral, and so it was considered by a committee of the Academy of Sciences at Paris, who reported on this subject.* This fact is most clearly seen by reference to the following table of analyses made in 1850.

LOCALITIES.	$\dot{S}i$	$\dot{A}l$	Ca	Fe	Mg.	K & Na	H	Mn	
Gumuch-dagh,	29·66	50·88	13·56	1·78	0·50	1·50	3·41	——	J. L. Smith
Island of Nicaria,	30·22	49·67	11·57	1·33	*trace*	2·31	5·12	——	"
" "	29·87	48·48	10·84	1·63	*trace*	2·86	4·32	——	"
Island of Naxos,	30·02	49·52	10·82	1·65	0·48	1·25	5·55	——	"
" "	28·90	48·53	11·92	0·87	not est'ed	not est'ed	5·08	——	"
" "	30·10	50·08	10·80	not esti'ed	"	"	4·52	——	"
Gumuch-dagh,	30·90	48·21	9·53	2·81	"	"	4·61	——	"
" "	31·93	48·80	9·41	1·50	"	2·31	3·62	*trace*	"
Siberia,	28·50	51·02	12·05	1·78	"	not est'ed	5·04	——	"
Village Green, Pa.	32·31	49·24	10·66	——	0·30	2·21	5·27	——	W. J. Craw
"	31·06	51·20	9·24	——	0·28	2·97	5·27	——	"
"	31·26	51·60	10·15	——	0·50	1·22	4·27	——	"
"	30·18	51·40	10·87	——	0·72	2·77	4·52	——	"
Buncombe Co., N.C.	29·17	48·40	9·87	——	1·24	6·15	3·99	HF 2·03	Silliman, Jr
Unionville, Pa.,	29·99	50·57	11·31	——	0·62	2·47	5·14	——	W. J. Craw
"	32·15	54·28	11·36	*trace*	0·05	not est'ed	0·50	——	Hartshorne

It was suspected by us, at the time the species was made, that it might prove identical with margarite, but not having the latter mineral at hand, we had to proceed on the known analyses of it which we here give. The 1st is by Dumeril; the second by the Göttingen Laboratory on the authority of Hausmann.

	$\dot{S}i$	$\dot{A}l$	Fe	Ca	Na	H
1.	37·00	40·50	4·50	8·96	1·24	1·00=93·20
			Fe		Mn	Mg
2.	33·50	58·00	0·42	7·50	0·03	0·05=99·50

These analyses differing so materially from those of emerylite fully justified the formation of the species.

As soon as margarite could be procured, it was subjected to analysis and the inaccuracy of former analyses proved; but we

* Comptes Rendus de l'Académie des Sciences, Oct. 28th, 1850.

had not at that time sufficient of the mineral to complete the investigation as desired. In the mean time Hermann* reanalyzed it, found a different composition from any previous one, and concurring with the one that had been made by us, as well as with those more recently made which are here given.

	$\ddot{S}i$	$\ddot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	$\dot{H}$	
1.	28·47	50·24	1·65	11·50	0·70	1·87	*trace*	5·00 =	99·26
2.	28·64		51·66	12·25	0·68		2·01†	4·76 =	100·00

These correspond to the formula

$$\dot{R}^3\ddot{S}i+3\ddot{A}l^2\ddot{S}i+3\dot{H}.$$

	Atoms.	At. weight.	Per ct.	Oxygen ratio.
Silica,	4	2309·24	30·58	4
Alumina,	6	3850·8	50·99	6
Lime,	3	1054·5	13·96	1
Water,	3	337·5	4·47	1

The specimen of margarite examined was received from Dr. Krantz of Bonn, and came from Sterzing in the Tyrol, the original locality.

By these analyses it will be seen that margarite and emerylite are identical, and the former name having priority of date (although the composition of the mineral was not made out until lately,) it must doubtless replace the latter, unless its geological appropriateness can sustain it.

2. *Euphyllite* of Silliman.

This mineral was first analyzed by Crooke, but the analysis having been made by a fusion with carbonate of baryta, was found to be incorrect. It was reanalyzed by Erni and Garrett.‡ Dr. Erni's analyses gave the formula, $\dot{R}^3\ddot{S}i+11\dot{R}\ddot{S}i+3\dot{H}$. Garrett found no water, his analyses give the same formula as Erni's, minus the water.

Our results differ essentially from those heretofore obtained, as is seen by the following analyses:

	1.	2.	3.	4.
Silica,	40·29	39·64	40·21	40·96
Alumina,	43·00	42·40	41·50	41·40
Peroxyd of iron,	1·30	1·60	1·50	1·30
Lime,	1·01	1·00	1·88	1·11
Magnesia,	·62	·70	·78	·70
Soda,	3·94	3·94	3·25	3·25
Potash,	5·16	5·16	4·26	4·26
Water,	5·00	5·08	5·91	6·23
	100·32	99·52	99·29	99·21

* J. f. pr. Chem., liii, 1. † By the difference.

‡ This Journal, [2], viii, 382; Dana's Mineralogy, 3d ed., p. 362.

No. 1 was from a specimen in our own collection. No. 2 was from the original specimen in Prof. Silliman's cabinet. Nos. 3 and 4 were specimens received from Messrs. Williams and Jeffries of Westchester, Pa. Sp. Gr. No. 1 and 2, 2·83. The analyses give the formula, $\dot{R}\,\ddot{S}i + \dot{R}_3\,\ddot{S}i_2 + 2\ddot{H}$.

	Atoms.	At. weight.	Per ct.	Oxygen ratio.
Silica,	3	1731·93	39·63	9
Alumina,	3	1925·40	44·05	9
Soda,	½	193·60	4·43	1
Potash,	½	394·42	6·74	
Water,	2	225·00	5·15	2

This mineral in its most beautiful form, is of rare occurrence (analyses 1 and 2 are of this variety); there is, however, another variety, not differing essentially in physical characters, or in chemical composition, which is found in considerable abundance at the locality.

In all probability the mineral alluded to as Muscovite? in the memoir on the minerals associated with emery* is this mineral; and when we may be able to get at certain specimens from Asia Minor, containing this mica in a pure state, this point will be investigated. It is of much interest towards tracing out its geological connection with corundum formations widely separated, in which respect it may resemble *emerylite*.

3. *Mica from Litchfield, Conn.*

This mineral is associated with the Kyanite of Litchfield. In general appearance it resembles margarodite. Hardness = 3·35, Sp. Gr. 2·76. Almost colorless, having a faint tinge of green. Transparent. Lustre pearly. The results of two analyses gave:

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}g$	$\dot{C}a$	$\dot{M}n$	$\dot{N}a$	$\dot{K}$	Fl	$\ddot{H}$
1.	44·60	36·23	1·34	0·37	0·50	*trace*	4·10	6·20	*trace*	5·26
2.	44·50	37·10		*undet.*	*undet.*	——	4·00	5·90	——	5·16

These correspond very closely with Liebnerite, as well as with Damourite, and some analyses of margarodite. Annexed are the analyses for comparison:

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{M}g$	$\dot{K}$	$\dot{N}a$	$\ddot{H}$	
Liebnerite,	44·66	36·51	1·75	——	1·40	9·90	0·92	4·49	Marignac.
Damourite,	45·22	37·87	$\dot{F}e$ *trace*	——	——	11·20	——	5·25	Delesse.
Margarodite,	46·23	33·08	3·48	*trace*	2·10	8·87	1·45	4·12	Delesse.

The silica and peroxyds† in these analyses are identical, but in common with many of the micas, it is extremely difficult to deduce any one formula that would be a correct expression of

* This Journal, [2], xi, 62.

† Considering the iron in Liebnerite as peroxyd.

their chemical constitution, owing to slight differences in the protoxyds. This is rendered more obvious by comparing their oxygen ratios.

	Ṙ	Ṙ	S̈i
1. Litchfield mica, ...	1 :	7·22 :	9·70
2. Liebnerite, ...	1 :	6·33 :	9·43
3. Damourite, ...	1 :	9·35 :	12·00
4. Margarodite, ...	1 :	6·16 :	8·95

The striking similarity of these species would lead us to suspect, that if new analyses were made of specimens from the original localities, they might prove identical. In all physical characters, except structure, there is a complete correspondence.

4. *Unionite, identical with Oligoclase.*

This mineral was described by Prof. Silliman, Jr., in this Journal, [2], viii, 384. The following are its characters. In general appearance it resembles a soda spodumene. It has a very distinct cleavage in one direction. Lustre vitreous. Color white. Hardness 6. Sp. Gr. 2·61. It is found with euphyllite at the corundum locality near Unionville, Pa. The results of three analyses are as follows:

	S̈i	Ä̈l	F̈e	Ċa	Ṁg	Ṅa	K̇	ign.
1.	64·09	21·45	*trace*	0·86	0·69	10·94	1·36	1·02=100·41
2.	64·45	20·97	*trace*	0·77	0·46	10·94	1·36	1·14=100·09
3.		21·70	*trace*	0·85	0·49	——	——	1·02

The third analysis, owing to an accident, is incomplete; the constituents determined are given for comparison. The oxygen ratio of these analyses is very nearly 1 : 3 : 9, which gives the formula $\dot{R}\,\ddot{S}i + \ddot{A}l\,\ddot{S}i^2$. This is the formula of oligoclase: the analyses correspond with that species, and the physical characters being the same, there can be no doubt as to the identity of Unionite and oligoclase.

It is believed that this is the first time that oligoclase has been observed in the United States.

5. *Kerolite of Unionville, Pa., a hydrated silicate of Alumina.*

Associated with euphyllite and Unionite, there occurs a peculiar amorphous mineral, which has been circulated among some American mineralogists under the name of Kerolite. In our examinations of the minerals from this locality, we thought it of sufficient importance to ascertain its chemical composition.

In physical characters it resembles Kerolite. Hardness 2·25. Sp. Gr. 2·22. Color yellowish white. Brittle. Crumbles to pieces when thrown in water. Analysis gave:

S̈i	Ä̈l	Ṁg	Ṁn	Ṅa & K̇	Ḧ
44·50	25·00	7·75	*trace*	*trace*	22·39=99·64

Of the water 1·04 per cent. were lost by 24 hours' desiccation over sulphuric acid, 8·81 per cent. by heating to 212°, and the remainder at a red heat.

In chemical composition it is near *halloysite*. It is an imperfectly formed mineral, and consequently is not homogeneous; it passes into euphyllite and felspar.

6. *Bowenite, identical with Serpentine.*

This mineral occurs at Smithfield, R. I., and was described by Bowen* as a variety of nephrite. His analysis gave:

$\ddot{S}i$	$\dot{M}g$	$\dot{C}a$	$\dot{F}e$	$\dot{A}l$	$\dot{M}n$	$\dot{H}$
44·69	34·63	4·25	1·75	0·56	*trace*	13·42

This composition differed so much from nephrite, and corresponded so closely to the formula $2(\dot{M}g\ \dot{C}a)^2\ \ddot{S}i+3\dot{H}$, that Prof. Dana felt himself justified in noticing it as a distinct species.†

The following are the physical characters of the mineral. Hardness 5, (it will scratch glass if rubbed with a little force against its surface; it first gives way, but ultimately scratches the glass.) Sp. Gr. 2·57. Color, in large masses, bright apple green. Highly translucent. Structure granular, and exceedingly tough. We give analyses of three specimens. No. 1 was from the cabinet of Prof. Silliman, Jr., No. 2 from the mineralogical collection of Harvard University, received from Prof. Cook, No. 3 from the Lederer collection in Yale College.

	$\ddot{S}i$	$\dot{A}l$	$\dot{M}g$	$\dot{F}e$	$\dot{C}a$	$\dot{H}$
1.	42·20	*trace*	42·50	1·56	*trace*	13·28=99·54
2.	42·56	*trace*	43·15	0·95	——	12·84=99·50
3.	42·10	*trace*	41·23	1·11	1·90	12·77=99·11

These analyses give the oxygen ratio 4 : 3 : 2, and the formula $2\dot{M}g^3\ \ddot{S}i^2+3\dot{M}g\ \dot{H}^2$, which calculated, is:

$\ddot{S}i$	$\dot{M}g$	$\dot{H}$
43·5	43·8	12·7

This is the composition, and formula of serpentine, and the fact of its identity with that species is also borne out by its physical characters.

The large amount of lime obtained by Bowen, was doubtless due to the limestone and tremolite with which it is often very intimately associated; much care is required to separate these substances entirely from the Bowenite, but the mineral so purified, contains no lime.

7. *Williamsite, identical with Serpentine.*

We notice that this species is considered distinct by Prof. Shepard in the last edition of his mineralogy, notwithstanding it has been shown to be serpentine by Hermann;‡ and previously from

* This Journal, [1], vi, 346.
† Dana's Mineralogy, 3d ed., p. 265.
‡ J. f. pr. Chem., liii, 31.

an analysis made by one of us, published in Dana's Mineralogy, page 692. In this analysis referred to, 3·35 per cent. of alumina and iron were obtained; we have since examined the relative proportions of these substances, and find that the amount was due to iron with but a trace of alumina. Two analyses, made from very pure specimens, gave:

	Si	Al	Mg	Fe	Ni	H
1.	41·60	*trace*	41·11	3·24	0·50	12·70=99·15
2.	42·60	*trace*	41·90	1·62	0·40	12·70=99·22

It is evident from these analyses that the mineral is identical with serpentine, and affords the same formula as the mineral last mentioned. It may be well to remark that great care was taken to see that no magnesia accompanied the oxyd of iron in its precipitation by ammonia; not satisfied with adding an excess of sal-ammoniac to the solution before the addition of the ammonia, we re-dissolved the precipitate, added sal-ammoniac, and re-precipitated the oxyd of iron: this was done even a third time, before the last traces of magnesia were got rid of, or that we were sure that the amount of iron would not be increased by containing magnesia—a circumstance in which sufficient precaution is not always used. What is here said of oxyd of iron is equally true of alumina.

8. *Lancasterite; a mechanical mixture of Brucite and Hydro-magnesite.*

While on a mineralogical excursion to the localities near Texas, Pa., a few months since, in company with Mr. W. W. Jeffries, we observed at Wood's Mine a peculiar magnesian mineral, somewhat resembling Lancasterite; a chemical examination showed it to be *hydro-magnesite.* The composition of it, as well as its strong resemblance to some specimens of Lancasterite, led to a reëxamination of the latter species.

Lancasterite is described as occurring "foliated like Brucite," but sometimes in crystals "resembling somewhat stilbite or gypsum." As we desired to see whether these forms were identical in chemical composition, a portion of the foliated mineral was carefully selected, and the amount of carbonic acid determined—it was but a trace: the magnesia and water being estimated gave the same amount as is found in Brucite; there was also a trace of manganese and iron.

Some of the small crystals "resembling stilbite or gypsum," were then examined; analysis showed them to have the same composition as the hydro-magnesite of Kobell.

These results go to prove that Lancasterite is not a distinct species, but a mechanical mixture of Brucite and hydro-magnesite. In Dr. Erni's analyses of this mineral, (made in the Yale Laboratory,) we are aware he found great difficulty in obtaining

a constant composition, and it was only after a series of analyses that he obtained any concordant results. The specimens he examined were both crystallized and foliated, the folia in some cases overlying the crystalline portion. With this explanation the composition he obtained is easily understood.

The following are the results of our analyses. Nos. 1 and 2 were foliated. Nos. 3 and 4 were of the radiated variety.

	1.	2.	3.	4.
Magnesia,	66·30	66·25	42·30	44·00
Protoxyd of iron,	·50	1·00	*trace*	*trace*
" manganese,	*trace*		*trace*	*trace*
Carbonic acid,	1·27	*trace*	36·74	36·60
Water,	31·93	32·75	20·96	19·40
Direct determination of water,			20·10	

The foliated variety gives the exact composition of Brucite. In two determinations of loss by heat, the numbers 34·30 and 35·67 were obtained; great difficulty was found in obtaining the Brucite perfectly pure owing to its intimate association with the hydro-magnesite.

The radiated variety (as before stated) gives the composition of hydro-magnesite, and to show that the original analyses were made from a mixture of these minerals, we give Dr. Erni's results* for comparison.

Mg	Fe	C	H	Total.
50·01	1·01	27·07	21·60	99·69
50·72	·96	26·85	21·47	100·00

9. *Hydro-magnesite found crystallized.*

The hydro-magnesite above mentioned is extremely beautiful, and in appearance resembles very much the Thomsonite from Kilpatrick in Scotland. Its structure is highly crystalline and in some instances forms distinct crystals, which have been considered as monoclinic? (Dana); the diagonal cleavage is very distinct. Hardness 3–3·5 (scratching calcite with ease). Sp. Gr. 2·145–2·18. It occurs at Wood's Mine, Texas, Lancaster County, Pa., in seams which are sometimes half an inch in thickness, and at Low's Mine in veins, generally from one-tenth to one-fifth of an inch wide, having a beautifully radiated structure. The results of two analyses of a specimen from Wood's Mine are as follows.

	1.	2.
Magnesia,	43·20	42·51
Carbonic acid,	36·69	35·70
Water,	20·11	21·79
Iron and manganese,	*trace*	*trace*

* From Dana's Mineralogy, p. 213.

A direct determination of the water gave 19·83 per ct. These analyses give the oxygen ratio 2 : 3 : 2, and the formula

$$3(\dot{M}g\,\ddot{C}+\dot{H})+\dot{M}g\,\dot{H}$$

which calculated gives

$\dot{M}g$	$\ddot{C}$	$\dot{H}$
44·68	35·86	19·46

The composition and formula are the same as obtained by Kobell and Wachtmeister for hydro-magnesite from Negroponte and Hoboken.

We are not aware that this species has heretofore been observed with a crystalline structure.

10. *The supposed Magnesite of Hoboken, shown to be Arragonite.*

In connection with the foregoing investigations, it was thought that an examination of some of the anhydrous carbonates of magnesia might be interesting. For this purpose a specimen of magnesite from Hoboken, N. J., was submitted to analysis, (the variety referred to is that which occupies seams and cavities in the Hoboken serpentine, having an aggregated, fibrous structure and not unfrequently occurring in delicate needle crystals.) A careful qualitative examination of the needle crystals, showed them to be carbonate of lime, with scarcely a trace of magnesia; they have the form of Arragonite. Specimens from Staten-Island and the vicinity of Westchester, Pa., were examined, with like results. The crystals from the serpentine quarry near Westchester are frequently transparent and are among the most beautiful specimens of crystallized Arragonite that have been observed in this country.

Lab. University of Va., Jan. 18th, 1853.

ART. XXV.—*A Consideration of some of the Phenomena and Laws of Sound, and their application in the Construction of Buildings designed especially for Musical Effect;** by J. B. UPHAM, M.D., Boston.

"ARCHITECTURE," says Thomas Hope in his well known Historical Essay, "is essentially an art of direct utility."

It more than all others adapts itself to the tastes and habits and occupations of the people. Everywhere this fitness for a definite object, and adaptation of means to the end is apparent. It is an art, too, that keeps pace with the progress of the world, and deigns to accept whatever aids Science and Philosophy may offer for its improvement.

* The topics discussed in this paper formed the subject of a series of articles recently published in "Dwight's Journal of Music," under the title of "Acoustic Architecture." They are here given somewhat more at length, with such additional thoughts as a further investigation of the matter has furnished.

The connection which Music has with Architecture is analogous to that between the mind and the body. As the former requires for its due exercise the perfection of the latter, so music, when confined within the walls of a building, is dependent, for its full power and expression, upon a certain fitness and adaptation of form and construction. This fitness results, in part, from the associations naturally connected with some styles of architecture. Thus the forms of the ancient cathedrals are most befitting the majestic movements of the oratorio and the solemn mass. We there experience the most sublime effects of music, although this is a result to which the primary design of the architecture did not look. But we also find the deductions from modern science to correspond, in great measure, with these accidental relations; for the forms and proportions of the cathedral partake of those that we should now suggest for structures designed for musical effect. With as good reason, therefore, as the terms naval, military, and ecclesiastical, are applied to architecture, may we not claim for music also a distinctive department in this science?

The subject, in this view, has not yet received from the Profession the attention its interest and importance demand. Throughout the Continent of Europe, and especially in those portions of it we have been accustomed to regard as the home of the arts, this assertion will be found to hold true. While religion, as it should, has received most homage, and the receptacles for paintings and statuary (in latter years more particularly) are arranged with strict regard to their full and proper effect, music has rarely found a fitting abode. If we turn to our own country, this truth is still more apparent. Here, until quite recently, no building of this nature has been erected which has any claim to the observance of correct principles in its construction. England has, it is true, furnished some noble exceptions in this particular. The Birmingham Town Hall, and the Philharmonic Hall at Liverpool are still, without doubt, the finest structures of the kind in existence, and come very near the realization of perfect success.*

It is not our design in the present discussion to encroach at all upon the province of the professional architect, nor to attempt to put forth a theory which shall stand, unscathed in every point, the ordeal of a practical test. We are aware the subject is one beset with peculiar difficulties. Our knowledge of sound and of the laws of acoustics must still be considered very imperfect.

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* Within the past season the Boston Music Hall has been completed and dedicated to its appropriate use. This building embodies in its construction the results of a series of laborious investigations, and experiments made by a committee appointed for the purpose. Considering the uncertain deductions, hitherto of all scientific enquiry on this point, its success may justly be regarded as satisfactory and complete. It is a structure that confers honor alike upon its accomplished architect, and upon the city.

Many collateral circumstances, too, come in to complicate and disturb the best contrived theories of acoustic effect.

Within a few years past, several committees have been appointed by the English Parliament to consider, practically and scientifically, the whole matter, who have summoned before them the most eminent architects of the day, and after profiting by the learning and experience of all, have found their conclusions sadly at variance with each other. They found, too, that facts did not confirm the most plausible doctrines, and were almost led to question the truth of the fixed and immutable laws of science. Where the best authorities thus differ, and science and learning have failed to arrive at satisfactory results, it would be presumption in us to expect to point out a plan that will overcome all previous defects, or to hope to arrive, at once, at perfection. This, if done at all, can only be accomplished after much severe and patient investigation, aided by a series of costly experiments. All we can hope to do here, is to consider candidly what has already been said and written on this subject, and by careful comparison of facts, and the use of whatever further aids philosophy and research may have afforded us, endeavor to reconcile contradictory opinions, and, possibly, suggest a few additional inferences which may prove of practical utility.

We shall commence with a consideration of some of the facts and phenomena connected with the modern approved doctrine of sound, which have a practical bearing upon our subject.

According to the views of Herschell, sounds of all kinds agree in these particulars:

1. The excitement of a motion in the sounding body.
2. The communication of this motion to the air or other medium which is interposed between the sounding body and our ears.
3. The propagation of such motion from particle to particle of such an intermedium in due succession.
4. Its communication from the particles of the intermedium adjacent, to the ear itself.
5. Its conveyance in the ear by a certain mechanism, to the auditory nerves.
6. The excitement of sensation.

Herschell's idea (as set forth in his celebrated treatise in the *Encyclopedia Metropolitana*,) plainly is, that sound, when once produced, is governed by laws almost wholly analogous to those of light, and on this theory alone can its various phenomena be satisfactorily explained and made of practical value.

The propagation of the original impulse in air and other elastic fluid media has been best illustrated by the motion of waves upon the surface of a placid lake. If we drop a stone into a pool of water, a series of elevations and depressions chase each other rapidly along the surface, extending, with equal velocity in

every direction, till they gradually subside and mingle in the general level. The movement thus produced in the water, is apparent only. It is the impulse, communicated from particle to particle in the water of which the wave consists, not the motion of the water itself. Precisely analogous to this is the communication of sound in air, except that, in this latter case, as the impression is produced in, rather than upon, the surface of an elastic medium, it spreads equally every way, and would form, instead of concentric circles, concentric spherical laminæ.

The velocity of sound, as also its intensity, varies according to the nature and condition of the medium through which it is transmitted. In a dry atmosphere, and at the freezing temperature, sound travels at the rate of three hundred and sixty-three yards, or one thousand and ninety feet in a second. For every additional degree of Fahrenheit this velocity is increased about one thousandth part.

In the different gases this result is found to vary considerably, the velocity in hydrogen being nearly three times greater, and in carbonic and sulphuric acid gases much less than in common air. Through liquids the velocity is greatly increased, moving in water, at the temperature of 46° 6′ Fahrenheit, at the rate of four thousand seven hundred and eight feet per second.

The propagation or conduction of sound through solid bodies, presents many interesting points of consideration. Solids are good conductors in proportion to their hardness and elasticity, and uniformity of structure; and the better the conducting power of the material the more perfect will be its *resonance*, by which is here understood the power of aiding or increasing the intensity of the original sound. A series of experiments on the conveyance of sound along the cast iron pipes of Paris, instituted by MM. Biot, Bouvard, Malus and Martin, determined its velocity, in that metal, to be about 11,090 feet in a second, or ten and a half times greater than in air.

According to Chladni, the relative velocities of sound in different solids are as in the following table:

	Velocity, in feet, per second.
Tin, - - - - -	7,800
Silver, - - - -	9,300
Brass, - - - - -	11,800
Baked clay, - -	10,000 to 12,000
Copper, - - - -	12,500
Glass, - - - -	17,500
Iron,* - - - - -	17,500
Woods of various kinds, -	11,000 to 18,000

* It will be seen there is a great discrepancy between the result in iron as here stated, and that obtained by the experiments of Biot. Herschell observes that the error in this case throws a doubt on all the rest; unless, perhaps, steel be meant. —*Encyc. Metropol., Art. Sound.*

Of the woods, fir appears to be among the best conductors, sound being conveyed through it at the rate of 17,300 feet per second.

The intensity, also, of sound differs in media of different chemical and mechanical natures. It varies in atmospheric air with its density or specific gravity. Hawksbee, in his experiments detailed in the London Philosophical Transactions, with an atmosphere in the usual state, heard a bell at the distance of 30 yards. With a force of two atmospheres at 60 yards. With a force of three atmospheres at 90 yards. But he did not notice a corresponding increase of sound with greater densities.

Priestly ascertained by experiment that the sound of a bell in hydrogen gas was scarcely louder than in a vacuum, whereas both in oxygen and in carbonic acid gas it was louder than in air. M. Perrolle found that a sound, which ceased to be heard in atmospheric air at the distance of fifty-six feet, ceased to be heard in oxygen at sixty-three feet, in carbonic acid gas at forty-eight feet, and in hydrogen at eleven feet. Chladni also found that the sound from hydrogen gas in an organ pipe was feeble and difficult to distinguish, while that of oxygen was stronger than that of common air. If hydrogen gas be breathed for a few moments, the effect upon the voice is precisely the same as that noticed by travellers in ascending very high mountains; the vocal tones, in both instances, becoming enfeebled and raised in pitch.

In certain states of the atmosphere sounds are conveyed over water or a surface of frozen snow or ice with remarkable distinctness, and to an almost incredible distance. Instances are well authenticated, in which, under these circumstances, and in the clear still air of a winter's morning, a conversation has been carried on at distances greater than a mile. In the morning, before sunrise, the voice, and occasionally the laugh of the sailors on board of an English man-of-war at anchor off Spithead, have been heard at a place at Portsmouth, distant two and a half miles in a direct line. On the authority of Derham,* the human voice has been heard across the straits of Gibraltar, more than ten miles. The sound of a military band, at the hour of roll-call, has been heard at a distance of twenty-one miles from Edinburg castle.

The effect of sound propagated through mixed media is exceedingly curious and instructive, and, in connection here, deserves our careful consideration. We have already seen the facility with which an impulse is transmitted through a solid substance which is homogeneous and uniform in structure. But if the material or substance has different densities, or consists of different bodies imperfectly mixed, or is interrupted by empty

* Philosophical Transactions, 1708.

spaces, the sound will either be greatly diminished or entirely destroyed. As an analogous illustration of this, witness the difficulty with which light is transmitted through a glass filled with cracks, imperfections and impurities.

So, also, when the medium is a mixture of gases, vapors or liquids, or a combination of the one with the other, the effect, on both the velocity and intensity of the sound, is still more striking. Mr. Leslie found by experiment that, when the air of a receiver was only half exhausted and the deficiency supplied with hydrogen gas, the sound of an enclosed bell was thereby diminished so as to become scarcely audible. Recognizing, again, the analogy of light and sound, in this respect, Herschell thus illustrates its imperfect transmission through a mixture of different densities.

"When we add syrup to water, or brandy to water, and look through the glass at a candle before they have combined, the candle will appear like a cloud, or as if we had viewed it through a piece of ground glass. When the light passes from a portion of the water to the brandy, or from the brandy to the water, a part of it suffers reflection, and as the separating surface can seldom be perpendicular to the ray, a part of the light will also suffer refraction. Now, as this must take place many hundred times while the light is passing through a large glass of these imperfectly blended liquids, it is not difficult to understand how we are unable to see objects distinctly through the mixture. With sound the effect is precisely the same, but if the two media are of very different characters, the one a gas and the other a fluid, as in the case of falling rain, or the one a gas and the other a solid, as in the case of falling or newly fallen snow, the scattering and deadening of the sound is still more complete."

The effects here produced are attributed, as in solids, to a want of homogeneity in the medium or substance through which the sound is passed. The explanation given by Mr. Herschell is as follows:

"The sonorous pulses, in their passage through the mixture, are, at every instant, changing their medium. Now at every change of medium two things happen; first, a portion of the wave is reflected and the intensity of the transmitted part is thereby diminished; secondly, the direction of propagation of the transmitted part is changed, and the sonorous rays, like those of light, are turned aside from their direct course. Thus the general wave is broken up into a multitude of non-coincident waves, emanating from different origins, and crossing and interfering with each other in all directions. Now, whenever this takes place, a mutual destruction of the waves, to a greater or less extent, arises, and the sound is stifled or obstructed. But of all causes which obstruct the propagation of sound, one of the most effective is, the want of perfect adhesion at the juncture of the parts, of which such medium consists. The effect of this may be conceived, by regarding the superficial strata of molecules of each medium when in contact, as

forming, together, a thin film of less elasticity than either, at which, therefore, a proportionally greater reflection of the wave will take place than if the cohesion were perfect; just as light is much more obstructed by a tissue of cracks pervading a piece of glass than it would be by any irregularity in the composition of the glass itself. Further yet; as the parts of a non-homogeneous medium differ in elasticity, the velocities with which they are traversed by the sonorous pulses also differ, and thus, among the waves which do ultimately arrive at the same destination, in the same direction, some will arrive sooner, some later."

This will account for the phenomena of double sounds, sometimes heard in particular states of the atmosphere, and (it seems to us,) also, for the peculiar harshness and discordant nature of musical tones, when heard in similar circumstances. Every military band which attempts to play in the early morning, when the air is loaded with vapors, and the earth reeking with fogs and exhalations, is conscious of the unusual difficulty attending the effort, and the listener, under such conditions, cannot fail to remark the unsatisfactory nature of the music. Hence we can understand the importance of measures to preserve the air within a concert room in a uniform state.

On the other hand, it is a curious fact, that, in their passage through a bland and pure atmosphere, even inharmonious sounds will amalgamate and strike upon the ear with a pleasant accent. Space or distance, in this case, seems to act as a purifier of sound, sifting out and absorbing the discordant portions, and allowing only those without alloy to pass through. Mr. William Gardiner, author of "Music of Nature," appears to have first called attention to this peculiar fact. Its explanation may be found, in part, perhaps, in the greater permeating power of musical or harmonious sounds over mere noise (for such all discord may be termed) of the same intensity; but it must still be regarded, in great part, as one of the unexplained mysteries of nature. We shall have occasion, also, to refer to this principle, when we speak of the capacity of an apartment requisite to give to music its best effect.

A familiar illustration of the imperfections and alterations which occur in the communication of vibrations from one medium to another in immediate contact, when the homogeneity of either is disturbed, is obtained in the experiment originally made by Chladni:

"If we pour sparkling champaigne into a tall glass till it is half full, the glass cannot be made to ring by a stroke upon its edge, but emits a dull, disagreeable sound. This effect continues as long as the effervescence lasts, and while the wine is filled with air bubbles. But as the effervescence subsides, the sound becomes clearer and clearer, till at last, the glass rings as usual, when the air bubbles have disappeared. By reproducing the effervescence, the sound is again deadened as before. The cause of the result obtained by M. Chladni, is, says Mr.

Herschell, that the glass and the contained liquid, in order to give a musical tone, must vibrate regularly in unison as a system, and if any considerable part of a system is unsusceptible of regular vibration, the whole must be so."

In the case just mentioned, the sound is excited in a solid and transmitted to a fluid medium. The converse of this must also be true, i. e. when a sound passes from a fluid to a solid in contact with it, if this latter medium be not uniform and homogeneous in its structure. Thus every musical performance is modified essentially in its quality by the nature of the structure in which it is given; and hence the importance of attention, in this particular, to the choice of materials, and manner of constructing the walls of an apartment built for musical effect.

On some of the principles just stated can, also, be explained many facts and phenomena in the natural world.

The deep and awful silence which reigns in the elevated regions of the globe is owing, not only to the lack of the ordinary sounds of animated nature, but to the diminished density of the air acting, as we have seen, both to enfeeble and modify the powers of speech, and deaden the force of such sounds as actually exist.

The period of night seems peculiarly adapted to the formation and transmission of sound, especially musical sounds. If we may credit the reports of travellers, the tones of those birds in the equatorial regions which sing at night are singularly plaintive and melodious, as we know to be the case with the mocking bird, the whippoor-will and the nightingale. To certain sensitive minds, almost all sounds, at this season, partake of a musical character; to such there is melody in the running waters of a brook; the hum of insects is a song;—the voice of falling water mingles with the rising wind and the distant surging of the ocean to form a mighty chorus. The hush of nature, even, in the silent eloquence of night, is woven into harmony, and

> "The mute still air
> Is music slumbering on her instrument."

But the attention of the most unimaginative cannot fail, at such times, to be arrested by the prevalence of sounds of which they took no cognizance during the day. In the pure atmosphere that often prevails at night in tropical climates, such phenomena are particularly striking. Humboldt was of opinion that the noise of the great cataract of the Orinoco, when heard at night, in the plains which surround the mission of Apures, was three times louder than during the day. The explanation given by this eminent traveller, and repeated by Mr. Herschell, is as follows:

"In a hot day, when a warm current of air ascends from the heated ground and mingles with the cold air above of a different density, the transparency of the atmosphere is so much affected that every object

seen through it appears to be in motion, just as when we look at any distant object over a fire or flame of a candle. The air is, therefore, during the day, a mixed medium, in which the sounds are reflected and scattered in passing through streams and strata of different densities, as in the experiment of mixing atmospheric air and hydrogen. At midnight, on the contrary, when the air is transparent and of a uniform density, as may be seen by the brilliancy and number of the stars, the slightest sound reaches the ear without interruption."

In this greater distinctness of sounds by night, doubtless, something must be attributed to the absence of the usual noises of the day, and the consequent greater sensibility of the auditory apparatus to impressions; but the reasoning above given is philosophically correct.

It is a well known law, and one on which rests the entire fabric of music, as a pleasing Art, that sounds of whatever intensity move with the same velocity. Whether the original impulse be derived from the discharge of a cannon or the most delicate tones of the human voice—whatever be the quantity, pitch or quality of the original impulse, the sonorous wave reaches the ear in equal intervals of time. It would need but the slightest infringement of this law to change our highest enjoyment into the intensest suffering.

A general idea of the divergence and decay of sound is obtained from the illustration before given of dropping a pebble into an unruffled pool; if not interrupted by the surface of a wall or other obstacle, the wave thus produced spreads from its common centre, diminishing gradually in height till, at length, it sinks into the general level. So sounds in empty space, as ordinarily produced, diverge in all directions from the sonorous centre till their energy is lost in the distance. The intensity of sound decays in receding from its origin as the square of the distance increases.

The sympathy of sound and motion is exceedingly curious. Every fundamental note has its complimentary or harmonic adjunct, which an experienced ear can detect along with the original sound; and here the analogy with the phenomena of accidental or harmonic colors holds good. By a sympathetic communication of vibrations, the harmonic sounds can readily be produced.

"If two cords of the same material and equal tension be taken, the one being only one-third the length of the other, and the shorter string be sounded, the vibrations will be communicated to the other by the intervention of the air, which latter will vibrate in three parts each equal to the shorter string and each performing the same number of vibrations in a given time."

This tendency of one vibrating body to throw another into the same state of vibration, is well illustrated in the motion of two or more clocks fixed to the same support. For a long time it has

been known that clocks and watches in such a situation will modify each other's motions, and compel a perfect coincidence of action. So two chords or organ pipes, placed in each other's vicinity, and sounded together, will often be found in unison, though their respective notes differ a little when sounded separately. In this way, in a powerful orchestra, one or more refractory instruments are oftentimes compelled to play in tune. On much the same principle we would explain the requirement of harmonic relations in the proportions of a building constructed for musical purposes.

The subject of Catacoustics, or the doctrine of reflected sound, is, perhaps, the most unsatisfactory in its results of any branch of physical science; and, yet, upon its due appreciation depends, in very great measure, our hope of success in the attempt to make the laws of sound of any practical value in their application to the question under consideration.

This part of acoustics may be subdivided into *reflection proper* (which includes echo) and *reverberation*. Much indistinctness appears to have prevailed in the treatment of this subject by authors, as well as a singular want of discrimination as to the precise cause and effect, in the case of many phenomena which are commonly referred to the principle of reflection of sound, and many ingenious theories have been offered to explain the same result. Keeping in mind, however, the strict analogy heretofore observed in the laws of light and sound, it does not seem to us necessary to depart here from the idea of this intimate connection.

If an obstacle, as a blank wall, be interposed between the source of sound and the ear, the sonorous wave is thereby arrested in its direct course, and the indirect pulses only take effect. Could any contrivance be adopted which would mark the track of sound, the space behind such obstacle interposed would be left in shadow; and if water be the medium through which the sound is passed, the occlusion is still more complete, and would, in this case, be equivalent to a total eclipse, as we are taught by experiments actually made. But if the point of the original sound and the hearer be on the same side of the wall, and the ear in a favorable position, both the direct sound and the reflection from the surface of the wall will be heard, producing a reinforcement and slight prolonging of the original note or its distinct repetition, according as the hearer is nearer to or more remote from the reflecting surface.

These effects have often been confounded with resonance. By *resonance*, however, is intended something entirely distinct from reflection, depending, as we have previously seen, on a wholly different principle. By the former a musical tone is sustained and intensified, and, in this way, often improved, but reflection can never otherwise than mar the genuine musical effect, unless, indeed, the hearer is in such close proximity to the reflecting sur-

face that the original note and its reflection are received as one and the same sound. Of course, we must not be understood as speaking here of a single musical note sustained, but of the succession and combination of tones that go to form a musical idea. Resonance is well exemplified in the sounding-board of a pianoforte or the body of a viol, and is, in effect, *synchronous* with the original impulse, while reflection implies some interval between the primary and secondary or reflected sound. Now, in reality, this latter can never happen without some injury to the perfection of a sequence of musical sounds, though, practically, as above suggested, in a room of small dimensions the ear will scarcely be sensible of any confusion from this cause alone. It is in large apartments, (such as we shall see are essential, on other grounds, to the perfection of musical effect,) that we experience the disturbing influence of reflection, which therefore we must study to counteract and obviate by all the means which science has afforded us.

The laws which govern the reflection of sound are, as stated by Mr. Herschell, essentially the same as in the case of light; the angle of incidence, or the inclination at which the sound falls upon the wall, is equal to the angle of reflection or the inclination at which it is returned from the wall.

When the nature of the reflection is such as to cause a distinct repetition of the original sound, one or more times, it is called echo. As regards the nature of echo, and the conditions requisite for its formation, there exists still much uncertainty; it would seem to be but a modification of reflection, as just stated, but it also appears to possess some peculiar laws of its own. By some, it is supposed to be caused by unequal reflections of sound, as well as by conduction, and to require a free space beyond the reflecting surface. At the Marquis Simonetta's villa, near Milan, is a famous echo, where the voice is repeated forty times and the report of a pistol fifty-six times. It has been described by Addison and Keysler, according to the latter of whom it is occasioned by a reflection of the sound between the opposite parallel wings of the building, which are fifty-eight paces from each other, and at right angles to the main body of the structure; and yet the Jesuits erected a precisely similar edifice at Prague, but failed to produce an echo there. Doubtless the state of the atmosphere has something to do with the formation of echo, upon the principles stated in a previous paragraph. At the place first mentioned, according to Addison, the repetitions were more distinct and numerous in a fog. Saunders also states that a house in Lambeth Marsh produces echo in winter, but none in summer.

Very many remarkable echos have been found in our own country. The region of the White Mountains, as almost every one knows, abounds in them. As the writer was journeying in the

northern parts of Vermont, in the autumn of 1851, a singularly beautiful echo was noticed on the borders of a small lake, known as Island Pond. The voice, pitched on a high key, was answered distinctly thirty-six times, and the discharge of a fowling piece was followed by a prolonged roar which lasted for several seconds. This experiment was made on an evening following a balmy day in October. A dense forest skirted the opposite edge of the lake, from whose level a series of lofty hills rose in the form of an amphitheatre. The atmosphere had been hazy during the day; but the sky at the time was partially overcast, and the air moist and warm; rain followed the next day.

(*To be continued.*)

ART. XXVI.—*Considerations on the Theory of Chemical Changes, and on Equivalent Volumes;* by T. S. HUNT, of the Geological Commission of Canada.

IN the proposed inquiry we commence by distinguishing between the phenomena which belong to the domain of physics, and those which make up the chemical history of matter. We conceive of matter as influenced by two forces, one of which produces condensation, attraction, and unity, and the other expansion, repulsion, and plurality. Weight, as the result of attraction, is a universal property of matter. Besides this, we have its various conditions of consistence, shape and volume, with the relation of the latter to weight, constituting specific gravity, and the relations of heat, light, electricity and magnetism. A description of these qualities and relations constitutes the physical history of matter, and the group of characters which serve to distinguish one species from another, may be designated the *apparent* or *specific form* of a species, as distinguished from its *essential form.*

The forces above mentioned modify physically the specific characters of matter, but they have besides important relations to those higher processes, which give rise to new species by a complete change in the specific phenomena of bodies. In the capacity of such changes, consists the *chemical activity* of matter.

It is necessary to distinguish between the production of new species differing in physical characters, and that reproduction which belongs to organic existences. The distinction arises from that individuation which marks the results of organic life, and is eminently characteristic of its higher forms. The individuality not only of the organism, but of its several parts, is more evident as we ascend the scale of organic life, while inorganic bodies have a specific existence, but no individuality; division does not destroy them. Solidity or crystallization is a commence-

ment of individuation, and crystals like the tissues of plants and animals, must be destroyed before they can become the subjects of chemical change; "*corpora non agunt nisi sint soluta.*"

That mode of generation which produces individuals like the parent, can present no analogy to the phenomena under consideration; metagenesis or alternate generation, and metamorphosis, are however, to a certain extent prefigured in the chemical changes of bodies. Their metagenesis is effected in two ways, by condensation and union on the one hand, and by expansion and division on the other. In the first case, two or more bodies unite, and merge their specific characters in those of a new species. In the second case, this process is reversed, and a body breaks up into two or more new species. Metamorphosis is in the same manner of two kinds; in metamorphosis by condensation, only one species is concerned, and in that by expansion, the result is homogeneous, and without specific difference.

The chemical history of bodies is a record of these changes; it is in fact their genealogy. The processes of union and division embrace by far the greater number of chemical changes, in which metamorphosis sustains a less important part. By union, we rise to indefinitely higher species; but in division a limit is met with, in the production of species which seem incapable of farther division, and these being regarded as primary or original species, are called *chemical elements*. These two processes continually alternate with each other, and a species produced by the first, may yield by division, species unlike its parents. From this succession results *double decomposition* or *equivalent substitution*, which always involves a union followed by division, although under the ordinary conditions, the process cannot be arrested at the intermediate stage.

The prevalence of certain modes of division in related species, has given rise to the different hypotheses of copulates and radicals, which have been made the ground of systems of classification; but these hypotheses are based on the notion of dualism, which has no other foundation than the observed order of generation, and can have no place in a theory of the science. A body may divide into two or more new species, yet it is evident that these did not preëxist in it, from the fact that a different division may yield other species whose preëxistence is incompatible with the last; nor can the preëxistence of any species but those which we have called primary, be admitted as possible. Apart from these considerations, it is to be remarked that our science has to do only with phenomena, and no hypothesis as to the noumenon or substance of a species under examination, based upon its phenomena, or those of its derived species, can ever be a subject of science, for it transcends the limits of human knowledge.

For these reasons, it is conceived that the notion of preëxisting elements or groups of elements, should find no place in the theory of chemistry. Of the relation which subsists between the higher species, and those derived from them, we can only assert the possibility, and under proper conditions, the certainty of producing the one from the other. Ultimate chemical analyses, and the formulas deduced from them, serve to show what changes are possible in any body, or to what new species it may give rise by its changes.

Chemical union is interpenetration, as Kant has taught, and not juxtaposition, as conceived by the atomistic chemists. When bodies unite, their bulks, like their specific characters, are lost in that of the new species. Gases and vapors unite in the proportion of one volume of each, or in some other simple ratio, and the resulting species in the gaseous state occupies one volume, so that the specific gravity of the new species is the sum of those of its factors. The converse of this is true in division, and the united volumes of the resulting species, are some simple multiple of that of the parent; in metamorphosis a similar ratio is always observed.

Aside from the apparent exceptions about to be noticed, the weights of equal volumes of gases and vapors are their *equivalent weights*, and the doctrine of chemical equivalents is that of the equivalency of volumes. According to the atomic hypothesis, these weights represent the relative weights of the atoms, and as equal volumes contain the same number of atoms, these must have similar volumes, so that we come at last to the equivalency of volumes. As chemical combination is not a putting together of molecules, but an interpenetration of masses, the application of the atomic hypothesis to explain the law of definite proportions, becomes wholly unnecessary. Chemical species are homogeneous; "*tota in minimis existit natura.*" Solution is chemical union, as is indicated by the attendant condensation; mechanical mixtures are not accompanied by any change of volume.

As two volumes of water-vapor yield one volume of oxygen and two of hydrogen, this was assumed to be the equivalent of water, and of hydrogen, while oxygen was represented by one volume, whose weight was 8, that of the volume of hydrogen being ·5, so that the weight of the equivalent of water was 9. But two volumes of hydrogen unite without condensation, with two of chlorine, and the resulting four volumes of hydrochloric gas, are found to be equivalent to four volumes of chlorine, hydrogen, or water-vapor. Hence four volumes are to be taken for the equivalent of water, and it becomes H_2O_2, with an equivalent of 18, corresponding to HCl, and to volatile species generally, whose equivalents are represented by four volumes of vapor; from these, the equivalents of non-volatile species are determined by comparison.

Hydrogen, chlorine and some other primary species offer apparent exceptions to the general law of condensation and equivalency of volumes. When four volumes of chlorine unite with four of olefiant gas, or naphthaline, the product is condensed into four volumes; but if the chlorine unite with the same volume of hydrogen gas, there is no condensation, and eight volumes or two equivalents of hydrochloric gas are produced. This, however, is explained when we find that four volumes of the chloro-hydrocarbon MH,Cl_2, may break up into four of a new species M Cl, and four of H Cl, a change which with the chlorid of etherene is effected by the aid of hydrate of potash, and with the chlorid of naphthaline, takes place spontaneously at an elevated temperature. In the production of hydrochloric gas from chlorine and hydrogen, union takes place followed by immediate expansion without specific difference, or metamorphosis, while in its production with the hydrocarbons, we observe the intermediate stage.

If an equivalent of four volumes of hydrochloric gas were to undergo a change like the chlorid of naphthaline, and yield four volumes of chlorine and four of hydrogen, these species would appear with one-half their observed densities; hence we conclude that they are actually condensed to one-half their theoretical volumes, so that four volumes of hydrogen gas represent not H, but H_2. In the same way, if we conceive the quantity of oxygen produced from four volumes of water-vapor, to represent two equivalents, it should equal eight volumes instead of two, so that is condensed to one-fourth, precisely as the vapor of sulphur is condensed to one-twelfth of its theoretical volume. As there are no bodies which are known to yield for four volumes, a less quantity than two volumes of oxygen, this may be taken to represent its equivalent, and the condensation of the theoretical volume, is like that of hydrogen and chlorine, one-half. Water with an equivalent of four volumes is then H_2O, and its weight $2+16=18$; the same formula is deduced by those chemists who take two volumes for the equivalent, and dividing the weight of hydrogen, write water H_2O, with an equivalent weight of 9. The condensation of these elements is that mode of metamorphosis which constitutes polymerism, and evidently offers no exception to the law of equivalent volumes.

The law of Laurent "that the number of atoms of hydrogen, or of hydrogen, chlorine, nitrogen, metals, etc., in any formula corresponding to four volumes of vapor, is always a sum divisible by two," clearly follows from the principles already laid down, and from the fact that nitrogen, and the metals, are subject to the same conditions as hydrogen and chlorine; the *atoms* have the value which has been assigned to H, and to Cl in the formulas given above. The same rule of divisibility, as Laurent has already shown, necessarily holds in regard to the number of atoms

of carbon, as well as to the oxygen and sulphur, if we take for their equivalent weights, the numbers 6, 8 and 16 respectively.*

It is to be remarked that while the co-efficients of H, Cl or N, in formulas where these are associated, may be odd numbers, those of O, S, and C are always even; this seems a conclusive reason for doubling the equivalents of the latter, or dividing those of hydrogen, chlorine, the metals, etc., according as four or two volumes are taken for the equivalent.

I have elsewhere pointed out that carbon and oxygen sustain such relations, that C_2H_2 may be compared with O_2H_2 and with O_2M_2, and by the substitution of nitrogen for hydrogen, with C_2HN, prussic acid, and O_2N_2 nitrous oxyd, (the so-called compounds of nitrous oxyd with bases are probably O_2MN, corresponding to the cyanids, C_2MN;) while the peroxyd of hydrogen, O_4H_2, corresponds to O_4N_2, nitric oxyd, and to C_4N_2, cyanogen. This relation has important bearings on the history of the cyanic series, and the nitric derivatives of the hydrocarbons.†

The formulas of such related species as Gerhardt has designated chemical homologues, differ from each other by nC_2H_2; if now the relation between C and O be what we have supposed, it may be expected that mineral species will exhibit the same relations as those of the carbon series, and the principle of homology be greatly extended in its application. Such is really the case, and the history of mineral species affords many instances of isomorphous silicates, whose formulas differ by nO_2M_2, as the tourmalines, and the silicates of alumina and magnesia, while the latter, with many zeolites, exhibit a similar difference of nO_2H_2. The relation is in fact that which exists between neutral and surbasic or hydrated salts.

Laurent has asserted that salts of the same base, with homologous acids of the type $(C_2H_2)nO_4$, may be isomorphous when they differ by O_2H_2, and has pointed out besides, several instances of what he has called hemi-morphism in species thus related, as well as in others differing by nCl_2. The observations of Pasteur and Nicklès have greatly extended the application of these cases, which assume a new importance in connection with the views here brought forward, and demand further study.‡

But to return: we have seen that in gases and vapors, the specific gravity of a species enables us to fix its equivalent, which

* See Laurent's Récherches sur les combinaisons azotées, Ann. de Chimie et de Physique, Nov., 1846, and the American Journal of Science for Sept., 1848, p. 174.

† See page 502 of my Introduction to Organic Chemistry, appended to Silliman's "First Principles of Chemistry," Phila.: 1852; and this Journal for January, 1853, p. 151.

‡ See Laurent, Comptes Rendus de l'Acad., t. xxvi, p. 353, and p. 257 of L. and Gerhardt's Comptes Rendus des Travaux de Chimie for 1848; also Pasteur, ibid., p. 165; and Nicklès, Comptes Rendus des Travaux, for 1849, p. 347.

is often a multiple by some whole number, of that calculated from the results of ultimate analysis. As the equivalents of non-volatile species are generally assumed to be those quantities which sustain the simplest ratio to certain volatile ones, the real equivalent weight corresponding to four volumes of vapor, and consequently the theoretical vapor-density of such species, is liable to a degree of the same uncertainty as those deduced from ultimate analysis. Having, however, determined the true equivalent of a species, from the density of its vapor, the inquiry arises whether a definite and constant relation may not be discovered between its vapor-density, and the specific gravity of a species in the solid state. Such a relation being established, and the value of the condensation in passing from a gaseous to a solid state being known, the equivalents of solids, like those of vapors, might be determined from their specific gravities.

A connection between equivalent weight and density is evident in some allied and isomorphous species. H. Kopp, in dividing the assumed equivalent weights of such bodies by their specific gravities, obtained quantities which were found to be equal for some of these related species. These numbers evidently represent the volumes of equivalents, and in accordance with the atomic hypothesis, are said to denote the *atomic volumes*. The inquiry of Kopp has been pursued by many investigators, among whom are Schrœder, Filhol, Playfair and Joule, and more recently, Dana. Their results show that the volumes thus calculated for related species of similar crystallization, are generally identical, or sustain to each other some simple ratio; while Mr. Dana, who has compared isomorphous species of unlike chemical constitution, finds that the calculated volumes are often to each other, as the number of equivalents of elements, in the formulas representing the species; thus leading to the conclusion that the real equivalent weight is either a mean of that of all the elements, or some multiple of it. The reason of this appears in the fact that the formulas of those species in which this relation is apparent, generally differ in the proportions of Al_2O_3, SiO_3, MgO, CaO etc., and the quantities obtained in dividing the equivalent weights of these by the number of elements, are nearly equal. If we divide by the number of elements, the equivalents calculated from the formulas of those species, it will be seen that the mean equivalents vary with the specific gravity.

These investigations have been principally confined to native and artificial mineral species, and the equivalents have been calculated from the formulas of Berzelius and Rammelsberg, which express the simplest ratios deducible from analysis. While in conformity with the dualistic notions, a mineral like calcite or magnesite was regarded as a compound of one equivalent of carbonic acid and one of lime or magnesia, dolomite was said to be

composed of one equivalent of each of these carbonates, or of two to three, as the case might be, while its density was the mean of those of its constituents; thus implying that this union, unlike that observed in gases, is juxtaposition, and not interpenetration. This system of formulas has introduced such difficulties into the study of the relations before us, that we find Mr. Dana led to the conclusion that "the elemental molecules are not combined together or united with one another, in a compound, but that under their mutual influence, each is changed alike, and becomes a mean result of the molecular forces in action."*

The solution of these difficulties is very simple, and will have been inferred from the plan of our inquiry. It is found in the principle that *all species crystallizing in the same shape, have the same equivalent volume;* so that their equivalent weights, as in the case of vapors, are directly as their densities, and the equivalents of mineral species are as much more elevated than those of the carbon series, as their specific gravities are higher. The rhombohedral carbonates must be represented as salts having from twelve to eighteen equivalents of base, replaceable so as to give rise to a great number of species, and the variations in the volume of different carbonates, as observed by Kopp, indicate the existence of several homologous genera, which are isomorphous.

The researches of Playfair and Joule have led them to the conclusion that in some hydrated salts which crystallize with twenty and twenty-four equivalents of water, as the carbonate, the triphosphates and triarseniates of soda, the calculated volume, coincides with that obtained by multiplying the volume of ice (9·8 for HO with an equivalent weight of 9;) by the number of equivalents of water. This result is thus explained; water in these salts is in the same state of condensation as in ice, and 24 HO thus condensed would occupy the volume of $24 \times 9{\cdot}8 = 235{\cdot}$, which is identical with that of the rhombic phosphate, as $20 \times 9{\cdot}8 = 198{\cdot}$ is with that of the carbonate of soda, $C_2Na_2O_6$, 20 HO. Alum, crystallizing with 24 HO, has a volume which is greater than that of phosphate of soda, and according to Playfair and Joule, equals that of the water in the state of ice, with the addition of the bases, the acid being excluded.† In reality, the equivalent volume of alum is to that of the rhombic phosphate as 270 : 235, and 24 HO crystallizing in the monometric system, would have the same volume as alum, with a specific gravity of about ·8, giving for HO, 11·25 instead of 9·8.

What are called the atomic volumes of crystallized species are the comparative volumes of their crystals. In the rhombohedral system, the length of the vertical axis being constant, the volume

* This Journal, [2], vol. ix, p. 245.

† Chem. Soc. Quar. Journal, i, p. 139, cited in Liebig and Kopp's An. Rep., 1847–48, vol. i, p. 30.

varies with the length of the lateral axes, or in other words, increases as the rhombohedron becomes obtuse, and diminishes as it becomes acute, the cube being the limit between the two. So in the dimetric and trimetric systems, the length of the vertical axis being unity, the volume diminishes as the base of the prism, the specific gravity increasing. Monoclinic and triclinic crystals may be calculated as if derivatives of the trimetric system, with which they will be found to correspond in volume.

It is now necessary to determine what equivalent corresponds to a given specific gravity in any crystalline solid, or in other words, what is the value of the condensation which takes place in the change from the gaseous to the solid state; and here a degree of uncertainty is met with, because the equivalent of a crystallized species may often be a multiple of that deduced from those chemical changes, which only commence with the destruction of its crystalline individuality. The simplest formula deducible for alum is $KOSO_3, Al_2O_3 3SO_3, 24HO$, or $S_4K_2al_3O_{16}, 12H_2O_2$, and hydrogen being unity, its equivalent is at least 474·6, which with a specific gravity of 1·75, gives a volume of about 270. Again grape sugar is not less than $C_{24}H_{24}O_{24}$, if we regard its combination with common salt as corresponding to one equivalent of each, and the ferrocyanids in the same way are represented by C_{12}, etc.; there are reasons for believing that the equivalents of these species in the crystalline state, correspond to some multiple of the above formulas, a question to be decided by an examination of the crystallization and specific gravity of species whose equivalents are admitted to be higher.

Fabve and Silbermann from their researches upon the heat evolved in fusion and solution, have been led to conclude; first, that crystallized salts are polymeric of these same salts in solution, i. e., are represented by formulas which are multiples of those deduced from analysis; secondly, that double salts, and acid salts do not exist in solution, being produced only during crystallization; and thirdly, that water in crystallizing, changes from HO to nHO, n being some whole number.* These conclusions are seen to be in accordance with those deduced from a consideration of the relations of density and equivalent volume; a polymerism is evident in such salts as sulphate of potash and cyanid of potassium, when their specific gravities are compared with those of alum and the ferrocyanid.

In the liquid state, the relation between specific gravity and equivalent is not so apparent in solid species. The condensation often varies greatly, even in allied and homologous species, but still exhibits a relation of volumes. The alcohols $C_2H_4O_2$,

* Comptes Rendus, xxii, 823–1140, and xxiii, 199–411; cited in Liebig and Kopp's Annual Report for 1847–48, vol. i, p. 40.

$C_4H_6O_2$, $C_{10}H_{12}O_2$, and $C_{16}H_{12}O_2$, have very nearly the same specific gravity, so that the condensation is inversely as their vapor-equivalents. The densities of wine-alcohol, acetic acid and aldehyd in the liquid state, vary as their equivalents, so that the calculated volumes are 57·5, 55·5 and 55. Formic and valeric acids show a similar relation in density to their respective alcohols, their calculated volumes being to these as 37·3 : 39, and 108 : 106·7. If to these we add butyric acid, which gives a volume of 90, and the density of whose alcohol has not yet been determined, the liquid volumes for the four acids $C_2H_2O_3$, $C_4H_4O_4$, $C_8H_8O_4$ and $C_{10}H_{10}O_4$, are 37·3, 55·5, 90, and 108. These numbers approximate to multiples of the liquid volume of water H_2O_2, which is 18; or taking this as unity, are very nearly as 2, 3, 5 and 6. The interval between 3 and 5 corresponds to propionic acid $C_6H_6O_4$, of whose specific gravity I find no recorded observation. The density of many of these liquids is not accurately known, and the results of different experimenters are not precisely accordant. The specific gravity at their boiling points should probably be chosen for the purpose of comparison, and these approximations lead us to expect that future observations will establish a simple relation between the densities of liquids and their vapors.

In a succeeding paper, it is proposed to apply the principles explained in the present essay, in an examination of the equivalents of a number of minerals and other crystallized species.

Montreal, C. E., Dec. 12, 1852.

ART. XXVII.—*New and ready method of determining the Alkalies in Minerals:* Part 1st—*The Quantitative Determination of the Alkalies in the siliceous minerals not soluble in Acids: with a note on a new method of forming the Protoxyd of Nitrogen;* by J. LAWRENCE SMITH, M.D., Professor of Chemistry in the University of Virginia.

1. IN the examination for alkalies in the class of minerals alluded to in this article, it is usual to devote a separate portion of the mineral to their special determination, without having reference to any of the other ingredients contained in the mineral. This method of proceeding naturally recommends itself; because a fusion with carbonate of soda is so greatly superior for the determination of all other ingredients, that even the attempt to control the result of the soda fusion by making use of the one for the alkalies, to arrive at the other substances as well as the alkalies, will in many instances embarrass the analyst as to his results.

2. It is only in cases of absolute necessity that one portion of the mineral should be used to estimate all its constituents, and

this condition of things will be alluded to in another part of this paper, as reference is now had to the quantitative determination of the alkalies, discarding whatever else the mineral may contain.

3. In the determination of the alkalies in silicates not soluble in acids, three important points present themselves:

I. The means necessary to render the silicate soluble.

II. The separation of the other ingredients from the alkalies, more especially magnesia.

III. The removal of the sal-ammoniac unavoidably accumulated in the process of analysis.

In all three of these, the processes adopted will be found to differ essentially from those now in use; and they are made known only after much experience by the author, in which their advantages have been most fairly tested, comparatively with methods already employed. In order that these processes may serve equally well in the hands of others, they will be given with some detail.

I. *Method of rendering the Silicate soluble.*

4. To render the silicate soluble, various plans have been proposed, all of which have their objections. Among the agents used for the purpose, are baryta and several of its compounds, viz.: the nitrate, carbonate, and chlorid.

5. The first of these is undoubtedly the best decomposing agent of the four, could we use a platinum crucible to heat the mixture of it and the mineral; as it is, a silver crucible is necessary, and this is not always capable of standing the requisite heat. According to Rose, "the silver crucible must be very strong, for if thin, the action of a red heat might crack it, and a portion of the fused mass would ooze out through the crevices." It also may happen that a heat higher than the point of fusion of silver is necessary to a complete decomposition of the mineral.

6. All that is here said of caustic baryta is equally applicable to nitrate of baryta.

7. The chlorid of baryum has been lately proposed; but its decomposing properties are very feeble, as the chlorine in combination with the baryum is not liberated at a white heat, and few silicates are able to produce the decomposition. It may succeed with some of the feldspars, but decomposes very imperfectly even the micas. So it is rather a risk to employ it with an unknown substance.

8. The carbonate of baryta is the compound of baryta most generally employed for silica decompositions; still this is attended with much difficulty, owing to the infusibility of this salt, and the impossibility of driving off the carbonic acid by heat alone; and even if this latter were possible, the objection pertaining to caustic baryta would then arise.

9. The following extract from Rose's Analytical Chemistry, (translation by Normandy, in a note by the translator,) presents fairly the difficulties attending this method of decomposing the silicates:

"The heat applied is so intense, that some precautions must be taken. The platinum crucible containing the mixture should be exposed first to the heat of an argand-lamp, and when the mass begins to agglutinate, the crucible should be closed, and its cover tied down with platinum wire, then placed in a Hessian crucible, closed up also; the whole is placed upon an inverted crucible, and submitted to the action of the blast of a wind furnace, beginning first gradually with a red heat, piling on more coke, so as to fill up the furnace, and increasing the heat to the highest possible pitch, until the Hessian crucible begins to soften. It is absolutely necessary to the success of the operation, that the Hessian crucible should be closed as well as possible, which is best done by luting the cover with fire-clay; the Hessian crucible and its cover having fused together, cannot be separated, except by breaking, &c., &c."

It will be seen in reading this extract, that the heat required is not ordinarily at the command of most chemists, in fact no other variety of furnace than a Sefstroem can be depended on for a complete decomposition.

10. Caustic lime and its salts have also been recommended and long used for the more imperfect decomposition of silicates, as for obtaining lithia from Spodumene and Lepidolite. Lime or its carbonate well mixed with many silicates finely pulverized, will decompose them completely at a white heat, but no one salt of lime is capable of meeting the demand of the entire range of alkaline silicates.

11. In consideration of these difficulties, Berzelius proposed the use of hydro-fluoric acid, and this method when applied with the numerous precautions required, will serve to decompose almost all silicates; still, according to Rose, there are silicious compounds that cannot be completely decomposed by hydro-fluoric acid. Besides, this acid is a most disagreeable one to manipulate with, whether we employ Brunner's apparatus, or Laurent's method, or what is always the best, the *concentrated acid*, previously prepared. I may also add, that the necessity of using sulphuric acid, after the decomposition is made, is another objectionable feature in this process.

12. The above furnishes a hasty review of the methods we are now possessed of for decomposing the silicates, in order to determine their alkalies; their merits can be contrasted with those of the method about to be described.

13. The decomposing agent which I present as a substitute for all others, and as capable of meeting the demands proposed in the commencement of this article, is *a mixture of carbonate of lime and fluor spar.*

14. Carbonate of lime I have used for more than six years for decomposing certain of the alkaline silicates, and more successfully than carbonate of baryta; still, in numerous instances, the decomposition was far from complete, and the method unsatisfactory. Notwithstanding these failures, I felt convinced that lime was the most powerful decomposing agent that could be conveniently employed for this purpose, as it could be used in its caustic state in a platinum crucible, without injuring the latter, although exposed to the highest temperature: when its carbonate is used, a red heat sufficed to drive off the carbonic acid and bring the mineral under the action of caustic lime, a circumstance that does not take place with carbonate of baryta; and it is well that it does not, for otherwise the platinum crucible would be seriously injured.

15. It was evident, that the only obstacle in the way of lime decomposing the silicates as thoroughly as caustic potash, was the impossibility of fusing the mixture, and thereby bringing the pulverized mineral and lime intimately in contact. This difficulty overcome, I felt confident of success. Without detailing the various methods resorted to, it will suffice to state that the object in view was, to use some flux along with the mixture of the silicate and lime, which would render the mixture fluid at a bright red heat. The two substances which recommend themselves, after many experiments, are the fluorid and chlorid of calcium, neither of which have any marked decomposing action on the silicates; in fact their action is simply that of fluxes, which enable the lime and silicate to come in contact in a liquid state, effecting nothing beyond that. It is with the *fluorid of calcium* that we have to do in this part of the paper, leaving the details on the use of the chlorid of calcium until farther experiments are made to test fairly its value.

16. The manner in which I proceed is as follows:

Pulverize the silicate to a sufficient degree of fineness—it is not required that the levigation be carried to any great extent; mix intimately, in a glazed porcelain mortar, a weighed portion of the mineral with one part of pure fluor spar, and four to five parts of precipitated carbonate of lime,* introduce it into a plati-

* The fluor spar used, is the transparent variety, free from all impurities; it is easily and abundantly procured in this as well as in all other countries. The carbonate of lime is made by dissolving calc spar or pure marble in hydrochloric acid, (the common acid may be used,) adding an excess of the carbonate; lime water or milk of lime is then poured on the solution until it is alkaline. By this means any oxyd of iron, alumina, or magnesia will be thrown down. To the filtered solution, a solution of carbonate of ammonia is added, and the precipitate washed several times with distilled water. It is best to prepare one's own carbonate of lime, for as a general rule, little reliance can be placed on the carbonates of lime, baryta, strontia, &c., sold as being precipitated by carbonate of ammonia, for in more than one instance, I have found the carbonate of baryta sold as a carbonate of ammonia precipitate, to contain soda.

num crucible capable of holding three times the bulk of mixed powder. The platinum crucible should then be placed in one of earthern ware, with a little magnesia on the bottom. (I always prefer the crucible made in France, called Beaufay's crucible to enclose platinum crucibles, when heated in a furnace, as their form and cleanliness make them superior to the Hessian crucible for this purpose.) The crucible may then be covered and introduced in any form of furnace where a bright red heat can be procured.

17. I have been using a common open portable furnace, heaping charcoal over the top of the crucible; and so easily does the effect take place, that in no instance has there been a failure of complete decomposition with as simple a means of heating as the above, and I have ascertained that an alcoholic lamp, with a large circular wick, such as Jackson's lamp, urged with a bellows, will answer for making a complete decomposition of Zircon in twenty-five minutes. This circumstance is not stated to recommend the use of a lamp for every mineral decomposition, when a simple portable furnace and charcoal are so accessible, and their effects so much more to be depended upon than a lamp. From 30 minutes to one hour's exposure to the heat is recommended.

18. It was an important point to test first how far this mixture could decompose the silicates without distinction as to their containing alkalies; for it was a very simple conclusion, that if those silicates most difficult of decomposition, and containing no alkalies, were completely decomposed by this process, all others must naturally give way under its action. The silicates experimented on, were *Zircon*, *Kyanite*, *Beryl*, *Topaz*, *Spodumene*, *Margarite*, *Margarodite*, and *Feldspars of different descriptions*. All were readily decomposed by the method just described, and without any particular care in levigating them; one gramme of the Zircon, for instance, after being crushed in the diamond mortar, was rubbed up for fifteen minutes in a large agate mortar, and used. Its complete decomposition was not only shown by its solution in hydrochloric acid, but by the amount of zirconia obtained—which was 64·8 per cent. with little iron. This concludes the first point to be considered in this article, namely, the means necessary to render the silicates soluble; the next point is the separation of the alkalies.

II. *Separation of the other ingredients from the Alkalies.*

19. The platinum crucible with its fused contents, is laid on its side in a capsule of platinum or porcelain, the latter can be used with perfect safety to the accuracy of the result. A quantity of dilute hydro-chloric acid is poured into the capsule, one part of acid to two of water; the whole is heated over a lamp,

when the contents of the crucible are rapidly dissolved out, the crucible is taken out and washed over the capsule, the contents of the capsule are then evaporated to dryness over a sand-bath, and if thought necessary, it may be completed over the lamp, without danger of the spitting which occurs in the soda fusion; this evaporation to dryness is not absolutely necessary, but the advantage of it is, that any great excess of hydrochloric acid is got rid of, and the precipitate in the next operation is less bulky than it otherwise would be.

20. To the dry mass a little hydrochloric acid is added, and then three or four ounces of water, or more, as the occasion may require; it is then boiled for a short time in the same capsule, allowed to cool down a little, and then a concentrated solution of carbonate of ammonia is slowly added until there is an excess of the same; the solution becomes at first quite thick with the precipitate, but in a short time (especially with a little warming over the lamp) the precipitate accumulates in a more or less granular state, and afterwards occupies less space in the filter than the alumina it might contain (in a feldspar, for instance,) were this latter precipitated separately by ammonia; and this circumstance is of much importance in diminishing the length of the operations and the amount of water accumulated by filtering it from several precipitates.

21. It will be seen that thus far, the operations have been carried on in the capsule in which the fusion was dissolved. The contents of the capsule are now thrown on a filter, but before doing this, it is well to pour on a little of the solution of the carbonate of ammonia, and see if the clear part of the liquid be rendered turbid, in other words, ascertain if sufficient carbonate of ammonia had been originally added.

22. The solution that passes through the filter contains much sal-ammoniac, the alkalies of the mineral, and a little lime. If magnesia be one of the ingredients of the silicate examined, some of this is also present; and in still rarer instances some of the earths soluble in carbonate of ammonia. This last complicates in no degree the remaining steps in the analysis. It is best to let the filtrate pass into a glass flask; the washings of the filter are collected in another vessel, and concentrated to a small bulk, added to the first filtrate, and the whole boiled for some time to drive off the carbonate of ammonia.* When no great haste is required in the matter, the whole filtrate (first portions as well as the washings) are collected in a beaker, and concentrated over a sand-bath. What remains now to do, is to separate from the alkalies the substances above alluded to. I commence by getting

* What remains in the filter is silica, alumina, fluorid of calcium, oxyd of iron, carbonate of lime, &c.

rid of the sal-ammoniac, and this brings me to the third part of this paper.

III. *The removal of the Sal-ammoniac unavoidably accumulated in the process of Analysis.*

23. This is probably one of the greatest annoyances to the analyst in his examination of minerals; first, from the manner in which the salt creeps up the sides of the vessel in which the evaporation to dryness is carried on, and secondly from the great difficulty of preventing loss of the chlorids of the fixed alkalies, during the volatilization of the sal-ammoniac. A better idea is formed of this by an experiment with a known quantity of the alkalies mixed with sal-ammoniac. An array of the precautions requisite to be taken, can be seen in Rose's last edition (German) pages 6 and 7. Owing to these difficulties, which my experience has often led me to contend with, the method about to be mentioned was contrived; it recommends itself both on account of its simplicity and certainty of operation.

24. Having some time back noticed the decomposing effect produced by heating sal-ammoniac with nitric acid, the nature of the decomposition was investigated to see how far it could be made use of to decompose entirely the sal-ammoniac; the result of the investigation was that the sal-ammoniac could be completely decomposed at a low temperature into gaseous products, and it was immediately adopted in my analytical process with the greatest satisfaction, both as to accuracy of results, as well as economy of labor.*

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* *Formation of almost pure Protoxyd of Nitrogen by the action of Nitric acid on Sal-ammoniac.*—The experiments made with the nitric acid heated with sal-ammoniac, to test the character of the decomposition, have resulted in the discovery of a new method for procuring protoxyd of nitrogen with the aid of a very low temperature. Among the experiments, the following were quantitative. Two grammes of sal-ammoniac were placed in a glass flask, and half an ounce of nitric acid poured upon it, the flask was connected with a small wash bottle containing a little water, and from this latter a tube passed into a pneumatic trough filled with hot water, heat was applied to the flask, and before the temperature reached 140° Fah., a gas began to be given off, and at 160° it came off rapidly, and continued to do so after the lamp was withdrawn. A small amount of red fumes appeared in the flask, that were condensed in the wash bottle, the gas that passed over was collected in a receiver, and measured 1008 cubic centimeters; the gas smelt of chlorine, the flame of a candle burnt with an increased brilliancy when introduced in it, the candle was re-ignited when extinguished, if a burning coal remained on the end of the wick—no red fumes were formed when it came in contact with the air, and the gas was absorbable by cold water. The properties were those of protoxyd of nitrogen. In another experiment the gases were collected at different stages of the process, in phials over hot distilled water, and a solution of caustic potash introduced and shaken up for some time; this latter was subsequently analyzed for the chlorine it absorbed, and in three different portions, collected at the beginning, middle and end of the process, the proportions of the chlorine to the whole bulk of the gas were $\frac{1}{57}$, $\frac{1}{29}$, and $\frac{1}{15}$. The amount of protoxyd of nitrogen due to the ammonia in two grammes of sal-ammoniac and its equivalent of nitric acid, is 887 cubic centimeters. The gas freed from chlorine, on being shaken up with cold water for some time, was

25. The manner of proceeding is as follows. To the filtrate and washings concentrated in the way mentioned (22) and still remaining in the flask, pure nitric acid is added—about three grammes of it to every gramme of sal-ammoniac supposed to exist in the liquid; a little habit will suffice to guide one in adding the nitric acid, as even a large excess has no effect on the accuracy of the analysis.

26. The flask is now warmed very gently, and before it reaches the boiling point of water, a gaseous decomposition will take place with great rapidity. This is caused by the decomposition of the sal-ammoniac in the manner described in the note. It is no advantage to push the decomposition with too great rapidity; a moderately warm place on the sand-bath is best adapted for this purpose. With proper precautions the heat can be continued and the contents of the flask evaporated to dryness in that vessel; but it is more judicious to pour the contents of the flask, after the liquid has been reduced to a half an ounce, into a porcelain capsule (always preferring the Berlin porcelain) of about three and a half to four inches diameter, inverting a clean funnel of smaller diameter over it and evaporating to dryness on the sand-bath or over a lamp. I prefer the latter, as at the end of the operation the heat can be increased to four or five hundred degrees.

27. By this operation, which requires no superintendence, one hundred grammes of sal-ammoniac might be separated as easily and safely as one gramme from five milligrammes of alkalies, and no loss of the latter be experienced. What remains in the capsule occupies a very small bulk; this is now dissolved in the

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found to be almost entirely absorbed by the water. What remained was a mixture of nitrogen and a little air, some nitrous or hyponitrous acid forms during the whole process, if concentrated nitric be used; if, however, it be diluted, little or none is formed, and the gas is readily given off at about 212° Fah.

In all my experiments, the protoxyd of nitrogen constituted from seven-eighths to twenty-four-twenty-fifths of the gaseous products, and when washed from its chlorine by a little lime-water or soda, possessed all the properties of pure protoxyd of nitrogen, and I would recommend it as a convenient way of forming this gas, especially when not required for respiration.

The character of the decomposition which takes place, is somewhat curious and unexpected. At first, I supposed that the decomposition resulted in the formation of equal volumes of NO, Cl, and N, but it appears that such is not the case, and that all but a very small portion of the ammonia with its equivalent of nitric acid is converted into NO; the liberated hydrochloric acid mixing with the excess of nitric acid; a little of the sal-ammoniac and nitric acid, does undergo the decomposition first supposed, and in this way only can the small amounts of chlorine and nitrogen be accounted for. At the time this method was first tried, I also tried the decomposing effects of nitrate of ammonia on sal-ammoniac, that has been shown by Maumené (Comptes Rendus, Oct. 15, 1851,) to result in the formation of chlorine and nitrogen; but the difficulty of controlling the decomposition once commenced, the puffing up of the mixture, and the necessity of having the salts dry to begin with, render this method (which was proposed by the author for forming chlorine) useless in processes for removing the sal-ammoniac in analysis.

capsule with a little water, (the funnel must be washed with a little water,) small quantities of a solution of carbonate of ammonia added, and the solution gently evaporated nearly to dryness. This is done to separate what little lime may have escaped the first action of the carbonate of ammonia or may have passed through the filter (22) in solution in carbonic acid. If any of the earths soluble in carbonate of ammonia existed in the mineral, those now become separated along with the lime.

28. A little more water is now added to the contents of the capsule, and the whole thrown on a small filter; the filtrate as well as washings are received in a small porcelain capsule. The liquid contains only the alkalies (as chlorids and nitrates) mixed with a minute quantity of sal-ammoniac. This is evaporated to dryness over a water-bath, and then heated cautiously over the lamp to drive off what sal-ammoniac may have formed (27) which is exceedingly minute if the process as pointed out be closely adhered to. It is not absolutely necessary to heat the capsule over the lamp, to get rid of the sal-ammoniac, for the little sulphate of ammonia which may be formed in the next step is easily removed in the final heating in a platinum vessel.

29. On the contents of the capsule, as taken either from the water-bath or as after being heated over the lamp, pure dilute sulphuric acid is poured (1 part acid, 2 water) and the contents boiled for a little time when all the nitric acid and chlorine in combination with the alkalies will be expelled; the acid solution of the alkalies is now poured into a platinum capsule or crucible, evaporated to dryness, and ignited. In order to insure complete reduction of the bisulphates into the neutral sulphates, the usual method must be adopted of throwing some pulverized carbonate of ammonia into the platinum capsule or crucible, and covering it up so as to have an ammoniacal atmosphere around the salt, which will ensure the volatilization of the last traces of free sulphuric acid. The alkalies are now in the state of pure sulphates and may be weighed as such. The manner of separating the alkalies from each other will be mentioned in the second part of this paper.

30. Thus far the mineral has been supposed to contain no magnesia. If this alkaline earth be present, we take the residue as found in the capsule, (26) dissolve it in a little water, then add sufficient pure lime-water,* to render the solution alkaline; boil and filter; the magnesia will in this simple way be separated from the alkalies. The solution which has passed through the filter is treated with carbonate of ammonia in the manner alluded

* If lime water be made it is well to make it of lime of the best quality, and the first two or three portions of distilled water shaken up should be thrown away as containing the small amount of alkalies sometimes present in lime.

to (27) and the process continued and completed as described (28, 29).

In the second part of this paper qualitative examinations of the alkalies in silicates will be alluded to, as well as the separation of the alkalies from each other.

Summary.—Fuse one part of mineral with one of fluorid of calcium and four to five of carbonate of lime; dissolve out the contents of the crucible with hydrochloric acid; evaporate to dryness and redissolve; precipitate with carbonate of ammonia; filter, boil and concentrate the filtrate; add nitric acid, heat and evaporate to dryness; dissolve the dry mass in a little water and treat with carbonate of ammonia; filter and concentrate, then add sulphuric acid, boil for a little while; pour in a platinum crucible, evaporate to dryness and ignite. If magnesia be present treat with lime-water prior to the last application of carbonate of ammonia.

Laboratory of the University of Virginia, Jan. 21st, 1853.

ART. XXVIII.—*Abstract of a Meteorologial Journal kept at Marietta, Ohio, for the Year* 1852: Lat. 39° 25′ N., and Long. 4° 28′ W. of Washington; by S. P. HILDRETH, M.D.

MONTHS.	THERMOMETER.						Winds.	BAROMETER.		
	Mean temperature.	Maximum.	Minimum.	Fair days.	Cloudy days.	Rain and melted snow in inches.		Maximum.	Minimum.	Range.
January, . . .	24·66	60	−23	13	18	2·08	N. & W. & S. & W.	29·80	28·65	1·15
February, . . .	35·23	60	12	15	14	3·66	W., S. W. & E.	29·75	28·55	1·20
March, . . .	44·53	76	12	12	19	4·30	N., N.W. & E. S.E.	29·90	28·98	·92
April, . . .	47·70	78	26	14	16	7·58	N. & W. & S. E.	29·44	28·55	·89
May, . . .	61·70	85	36	20	11	4·21	S. & S. W., N.	29·80	29·10	·70
June, . . .	67·33	88	42	21	9	5·70	S. & W. & N.	29·70	29·00	·70
July, . . .	73·00	92	51	27	4	3·84	S. S. W. & N.	29·64	29·08	·56
August, . . .	67·80	85	50	22	9	3·50	S., S. E. & N.	29·65	29·15	·50
September, . .	64·17	88	37	22	8	1·08	W., S. W. & S. E.	29·65	29·05	·60
October, . . .	58·00	86	33	19	12	2·30	S. W. & N.	29·60	29·20	·40
November, . . .	42·00	66	20	8	22	4·50	W., S. W. & S. E.	29·75	28·70	1·05
December, . . .	40·30	62	16	10	21	3·75	S. W., S., W., S. E.	29·70	28·90	·80
Mean for the year, .	52·20					46·50				

Remarks on the Year.—The mean temperature for the year is 52°·20, varying but little from the annual average of this locality. The extreme cold of January had no great influence in reducing the mean heat for the year. On the morning of the 20th of January the mercury in Fahrenheit, fell to 23° below zero at Marietta: at other points higher up the Muskingum

river, it sunk to 27°, 28°, and 30° below—at Union, five miles above the mouth, at 2 o'clock in the morning it had fallen to –27°; at sunrise it was at –23°—at Waterford, twenty miles above, the thermometer of my friend, Doct. G. Bowen, at 2 A. M. indicated a fall to –30° below; as daylight appeared it rose to –25° or –24° —at Zanesville it fell to –27°, and remained at that all the latter part of the night, being observed each hour by Mr. Coxe.

The cold seems to have travelled in currents or veins; being more intense in the valley of the Muskingum than in any other portion of the State. The centre of the river valley is from one hundred and fifty to two hundred feet lower than the adjacent country, and the coldest air being the heaviest, would descend into the lowest places. It has been remarked that the cold was greater in valleys than on the adjacent hills; and in localities not half a mile a part, a difference of ten or fifteen degrees has been often noticed when thus situated. At Cleveland, two or three degrees north of Marietta, the mercury fell to only sixteen below. Large bodies of water have an ameliorating effect on climate, but as the lake was nearly covered with floating ice, it could have had little influence in lessening the intensity of the cold. The surface of the earth was covered with snow about ten inches deep, which aided much in giving effect to the frost. At the time of the severe weather in February, 1818, the snow at Marietta was two feet deep; on the 8th of that month the mercury stood at 22° below zero, and on the 9th at 20° below: while in 1852, the cold was intense only on one night, being at zero only on the 19th, and twelve above on the 21st. The longer continuance of cold in 1818, was more destructive to trees and shrubs than at this time, killing sassafras and spice bush, with every peach tree in the country down to the surface of the snow. It now destroyed the peach in low grounds but not on the hills—also quince trees, killing the fruit buds and small branches of the Catawba and Isabella grape, so that my vines produced only a few scattering clusters. The wood of the Pyrus japonicus was generally killed down to the ground or the surface of the snow; especially the variety with flesh colored blossoms, which is less hardy than the scarlet: several other Chinese plants suffered severely from the cold, amongst which was the tree peony Spirea prunifolia brought out by Mr. Fortune a few years since, was nearly destroyed; Weigelia rosea and Forsythia viridisima, stood the trial very well, the latter being partly protected by a piece of matting. The Weigelia bloomed in great perfection, and is one of the most beautiful of all the hardy flowering shrubs that I have seen. Even our native evergreens, Kalmia latifolia, and Rhododendron, suffered severely in their flower buds, not opening a single blossom. Chinese Arborvitæ was killed outright. The Judas tree was dressed in mourning,

not showing any of its rich purple flowers; while the Cornus Florida was not at all disturbed, but bloomed with the usual profusion and beauty. Coming as it does at the same time with the Judas tree, the latter was much missed on the hill sides and forrest openings. It will take several years to replace our peach orchards in their former flourishing condition.

The amount of rain and melted snow for the year is forty-six inches and fifty-hundredths; being somewhat over the average amount, which may be placed at forty-two inches, or three and a half feet. The greatest quantity in any one month, fell in April, being seven inches and $\frac{7}{100}$ths. The rain was pretty equally distributed, falling at those times where most needed for the sustenance and growth of plants.

Winter.—The mean temperature of winter was 29°·29, which is several degrees below the usual mean.

Spring.—The mean of the spring temperature was 51°·31, and is rather lower than common, it often being about equal to the mean of the year. Vegetation was rather backward; vernal flowers seemed shy of appearing, and kept behind their usual time. On the 24th of March, there was quite a noted snow storm, falling near four inches, but melting soon after; it had but little influence on the temperature, the mercury standing at 36° and 40° during its continuance. In April the Ohio river was visited with a flood that covered all the bottom lands—on the Monongahela, at Brownsville, the water was higher than at the great flood of 1832—at Pittsburgh nearly as high—at Wheeling thirteen inches lower, and at Marietta four and a half feet below. It was at its height on the 20th and 21st of the month, with us; at Brownsville on the 17th; the water occupying about 72 hours in its descent, or traveling at the rate of one hundred miles in twenty-four hours. The flood is so much wasted, or taken up by the mouths of creeks, inlets, and a broader river-bed, that a rise of six feet at Pittsburgh, makes only two feet at Marietta, with all the aid of intervening affluents. At the period of its greatest height, plum, pear and cherry trees were in bloom, many gardens made, and fields of corn planted. The fruit of currants and gooseberries was destroyed, where covered by the water.

Summer.—The mean temperature of summer was 69°·38, which is rather low, being cool for this climate. July was the hottest month, being 73°. The greatest heat was 92°, while in August it was only 85°. In June it was not above 88°, so that the summer was a very agreeable and pleasant season; ripening the fruits in due time, and completing the growth of crops of grain and grass in great perfection.

Autumn.—The mean of autumn was 54°·72, showing a very mild and temperate season; there being no frost to destroy plants

until the 10th of November. The latter half of that month was cold and stormy, with flights of snow.

Floral Calendar.—March 8th, Pewee heard; 10th, Yellow Crocus in bloom; 15th, white and purple Crocus; 17th, Hepatica triloba—a week later than usual; 19th, Cat-bird heard, Crown Imperial one and a half feet high.

April 3d, Crown Imperial in bloom; 11th, Sanguinaria Canadensis, Hyacinth; 17th, Plum and Imperial Gage; 23d, Peach in bloom on the hills, where it escaped the cold of January; 26th, Pear tree; 27th, Apple tree—it is usually a week or more behind the Peach, but this year nearly at the same time.

May 8th, Quince in bloom, where it escaped the cold; 9th, Cornus Florida; 13th, Tradescantha virg.; 14th, Weigelia rosea, Syringa fragrans; 15th, Mocasin flower, yellow and white; 24th, Locust tree; 27th, Syringa Philadelphica.

June 18th, White Lily, and Amaryllis formosissima; 21st, Red Raspberry ripe; 28th, Wheat harvest begins; 29th, Asclepias decurrens in bloom.

July 2d, Actea racemosa in bloom; 4th, Early Chandler apple ripe; 22d, Blackberry ripe.

ART. XXIX.—*On a probably new element with Iridosmine and Platinum, from California;* by Dr. F. A. GENTH.*

I RECEIVED from Dr. Charles M. Wetherill a small quantity of white grains, which were collected in 1849–50 from California gold by the late Jos. R. Reynolds, Esq. An examination of these grains furnished me results which are, perhaps, worth noticing.

I. When treated with boiling hydrochloric acid, two grains began to dissolve with disengagement of hydrogen. As soon as I observed this reaction, I picked them out and washed them off with water. With a good magnifying glass I found that they were mechanically mixed with gold. Their color was between a tin-white and steel color; they were malleable, but harder than tin; they dissolved in nitric acid, yielding a crystalline salt, the native gold which was mixed with them remaining undissolved. They precipitated copper from solutions but slowly. Hydrosulphuric acid precipitated the solution in nitric acid brown. A pure piece of the metal before the blowpipe on charcoal fused readily. It was soon covered with a black oxyd and gave no incrustations. Borax in the O. F. dissolved it and gave a colorless bead, which on cooling became opalescent; the same reaction took place more readily in R. F.

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* From the Proceedings of the Acad. Nat. Sci., Philad., Dec., 1852, p. 209.

The quantity of this metal was too small for further experiments, but these reactions show that it is neither tin nor any other known element, although it has some relations to tin; but it is distinguished from it—

1. By its solubility in nitric acid.
2. By its brown precipitate with hydrosulphuric acid.
3. By not being readily oxydized before the blowpipe into a white oxyd, and by its other blowpipe-reactions.

May not the grains of native tin observed by Hermann in the auriferous sands from Siberia be the same substance?

II. An examination of the white grains, which were insoluble in hydrochloric acid, gave (after a few scales of native gold had been extracted by quite diluted aqua regia) the following results.

Of 0·9366 grms. were 0·4625 grms. or 49·4 p. c. Sisserskite ($IrOs_4$) in brilliant lead-colored scales, some of which were imperfect six-sided prisms.

The remaining grains and scales (0·4741 grms.) had a tin-white color and were treated with aqua regia, as long as it acted upon them. Three rounded grains remained undissolved in aqua regia, which, I suppose, were Platin-Iridium. They weighed 0·0202 grms. = 2·2 p. c.

The balance of 0·4539 grms. or 48·4 p. c. was native Platinum.

The composition of the sample received by Dr. Chas. M. Wetherill was therefore

New element and gold,		not estimated.
Sisserskite, .	. .	= 49·4 p. c.
Platin-iridium,	. .	= 2·2 p. c.
Native platinum,	. .	= 48·4 p. c.

This native platinum is not pure, but contains, like that from other localities, other substances, both alloyed and mechanically mixed with it.

When the 0·4539 grms. were dissolved in aqua regia, 0·0031 grms. or 0·68 p. c. of Sisserskite remained undissolved in minute and fine scales.

The solution was evaporated to dryness in a water-bath, dissolved in alcohol and precipitated with chlorid of ammonium. The brick-red double salt thus formed was washed out with alcohol, then dried and powerfully heated. The ignited residue weighed 0·4206 grms. It was treated with weak aqua regia, which left undissolved 0·0110 grms. of Iridium and Rhodium = 2·42 p. c. (This is of course, only an approximate estimation of Iridium, etc.) This presence of Rhodium and Palladium was also ascertained, but I did not make any quantitative estimations, because the quantity I had to dispose of was entirely too small for the estimation of substances which can be separated only with the greatest difficulty.

The filtrate from the double salts of Platinum, etc., precipitated by ammonia gave 0·0432 grms. of sesquioxyd of iron = 6·66 p. c. of iron. The composition of this native Platinum is therefore

Platinum, (with palladium,) .	= 90·24
Iridium, (with rhodium,) .	= 2·42
Iron, ...	= 6·66
Sisserskite, ...	= 0·68
	100·00

Art. XXX.—*On the Causes which may have produced Changes in the Earth's Superficial Temperature;* by W. Hopkins, Esq., M.A., F.R.S., Pres. G.S., and Pres. Cambridge Phil. Soc. —With a Map.

(Continued from p. 86.)

1. *On the Height of the Snow-line and Descent of Glaciers below it at the present time.*

20. Knowing the mean annual temperature at any place on the earth's surface, we can calculate for that place the height at which the mean annual temperature of the atmosphere will be that of freezing, provided we know the rate at which the mean temperature decreases, in ascending from the lower into higher regions of the atmosphere. This rate has been determined with sufficient accuracy for our purpose. It is necessary to make a distinction between those observations which have been made in balloons or on the sides of comparatively steep mountains, and those which have been made on extensive elevated table-lands; the results in the two cases being very different. Of the first class, Humboldt has given us* the results of nine cases, in which the observations were made at different heights, varying from about 5,000 to 18,000 feet. The mean of the results gives 191·4 metres, or about 638 feet for 1° Cent., which is equivalent to 355 feet for 1° Fahr. In Gay-Lussac's balloon ascent, the observations gave 193 metres for 1° C., up to the height of about 12,000 feet. At greater heights the decrease of temperature was somewhat more rapid, and was at the rate of 1° for 187 metres for the whole height ascended, which amounted to upwards of 23,000 feet. We may adopt, without risk of material error, 190 metres for 1° C., or 350 feet for 1° F. In some particular cases, however, 320 feet would probably be nearer the truth.

Humboldt has also made some valuable observations, which show the effect of extensive high table-lands in raising the temperature above that which would be given by calculations found-

* Recueils Astronomiques of his Travels in S. America, vol. i, p. 129.

ed on the result just enunciated. In ascending from one table-land to another, the decrease of temperature is much slower than if we should ascend in a balloon, or up the side of a steep mountain. The following table exhibits the results of Humboldt's observations on four of the highest table-lands on the new continent:

Place of observation.	Latitude.	Height.	Mean temperature.	Increase of height for 1° C.
	° ′	metres.	C	metres.
Quito, - - - - -	0 13 S.	2907	15·0 C.	244·4
Popayan, - - - -	2 26 N.	1796	20·6	288·1
San. Fé di Bogota, -	4 35 N.	2660	16·5	256·0
Mexico, - - - - -	19 26 N.	2277	16·9	249·3

The mean of the numbers in the last column is 258·4 metres. This is equivalent to 478 feet of height for 1° F., instead of 350 feet, as in the former case. The high general temperature of the plains of Tibet (as indicated by the nature of their produce), in proportion to their enormous elevation, is doubtless due to the same cause.

From these results it appears, that we may take a decrease of 1° F. as corresponding to an elevation varying, according to circumstances, from 320 to 500 feet; the smaller number being applicable to small, or, if high, very steep mountains, and the latter to large massive ranges presenting extensive table-lands along their sides. For intermediate cases, intermediate numbers must be adopted.

21. Before the publication of the admirable observations of Humboldt, it was usually assumed, in speculations respecting the line of perpetual snow, that it coincided with that of 32°. Later observations have shown the error of this hypothesis, especially in the higher latitudes. Humboldt has given the following results, deduced from his own observations and those of others, respecting the mean annual temperature at the limit of perpetual snow, in different latitudes:

At Chimborazo, lat. = 1°·28′ S.	Mean temperature of the snow-line	= 32° + 2°·7 = 34°·7 F.
At St. Gothard, lat. = 46° N.	" "	= 32° − 6°·7 = 25°·3
At the Polar Circle	" "	= 32° − 10°·8 = 21°·2

Hence it follows that near the equator the snow-line is nearly 1000 feet lower than that of 32°, while at St. Gothard it is higher than this latter line by about 2000 feet, and at some places on the polar circle by about 3500 feet, according to Humboldt. But in that latitude in the northern hemisphere the height of the snow-line above that of 32° appears to be very variable, as might be expected from the very different conditions under which different regions are situated along the same parallel of latitude. In

north-eastern Asia it is probably much greater than 3500 feet, while in Iceland the two lines must nearly coincide.

I am not aware of other similar observations on the temperature of the snow-line, or on the relative heights of that line and of the line of 32°. The height of the snow-line, however, has been ascertained in several other places, and the height of the line of 32° F. may be calculated, and their relative positions determined. Thus for the Pyrenees (lat. = 42° 30′) we have by observation,—

Height of snow-line . . . . . = 9300 feet.

The mean annual temperature at the level of the sea may be taken at 56°, and therefore the decrease up to the line of 32° will be 24°; and, allowing 320 feet ascent for a decrease of 1° F., we shall have,—

Height of the line of 32° . . . . = 7680 feet.

Consequently the height of the snow-line will exceed that of the line of freezing temperature by 1620 feet.

A similar calculation for the Caucasus (lat. 42° 30′), where the height of the snow-line is rather more than 10,000 feet, gives the height of the line of 32° less than 8000 feet, and therefore lower than the former by about 2500 feet. And again, for the Himalaya we have similar results. On the south side of this range, in latitude 32° N., we may take the mean annual temperature, independently of elevation, at 67° F., or 35° above the freezing temperature, and, allowing 400 feet for a decrease of 1° F. in ascending the southern slope of the mountains (§ 20, p. 248), the height of the line of freezing temperature will be 14,000 feet. The height of the snow-line, as given by Captain Strachey, is there 16,000 feet, or 2000 feet higher than the former line. On the north side of the range, allowing 2° F. in the mean annual temperature, independent of elevation, for the difference of latitude as compared with the south side, and 480 feet of ascent for each degree of temperature (§ 20), we have 15,840 feet for the height of the line of 32°. Also we have, on the same authority as the above, the height of the snow-line 18,500 feet, or upwards of 2600 feet above the former line.

These calculated results as to the difference of heights of the snow-line and that of the temperature of 32° may not of themselves be entitled to much confidence, compared with those deduced from observation; but they show that the data on which the calculations are founded are in accordance with the results of observation in other cases.

22. It appears from the preceding facts, that the height of the snow-line, with reference to the line of 32° F., increases, under similar conditions, as we proceed northward from the equator. For this phenomenon we may assign two principal causes, which

it is important for us to notice, in order that we may be able the better to understand the real analogies between actual cases of observation and the hypothetical cases of past geological epochs.

At places near the equator, and especially at great elevations, there is little variation of temperature from one season to another. Let us suppose a case in which the temperature should be entirely equable. The snow-line would be absolutely stationary. Above this line the snow would tend to accumulate by constant deposition, until this tendency should be exactly counteracted by destructive causes, such as the direct action of the sun's rays, evaporation, drifting by the wind, avalanches, &c. The snow-line would be that beneath which these antagonistic causes would cease to be in equilibrium, and its position would manifestly depend *cæteris paribus* on the quantity of snow produced in the atmospheric region directly over that upper portion of the mountain which should be bounded by the snow-line. If the quantity of snow thus formed and falling on the mountain should be very small, the destructive causes would not allow it to remain permanently at so low a level as that of the line of freezing temperature, which might in this case be considerably below the snow-line. On the contrary, if a comparatively large quantity of snow should fall on the mountain, the snow-line might descend to a considerable distance below that of freezing temperature.

But let us now suppose the annual temperature to vary from summer heat to winter cold, the *mean* annual temperature remaining the same. It is manifest that the variable snow-line during the year would in winter be below, and in summer above the permanent snow-line of the previous case, the extent of this oscillation being proportionate to that of the temperature during the year. But the highest or summer position of this variable snow-line is what is properly called *the snow-line*. Thus, while, with a temperature in which the variation from summer to winter should be comparatively small, the snow-line should be below the line of freezing temperature, it might be far above that line if the oscillation of temperature were great, although the *mean* annual temperature should be the same in both cases.

Considering then the position of the snow-line with reference always to the line of 32°, the conditions which produce its lowest positions are those which secure a moist atmosphere with an approximately equable annual temperature. Comparing places in the same latitude, an insular position will have a lower position of the snow-line than a continental one. In comparing a place near the equator with one in the higher latitudes, there will be much greater humidity in the atmosphere and much less variation in the annual temperature in the former case than in the latter, and both these causes tend to produce a much lower posi-

tion of the snow-line, with reference to the line of 32°, in the former case than in the latter. These general causes, independently of the action of mere partial causes, are sufficient to explain the general results of observation above given.

23. After the preceding considerations respecting the relative positions of the line of 32° F. and the snow-line, I proceed to examine the distances, measured vertically, to which the principal known glaciers descend below this latter line, which forms the limit of a glacier's superficial increase. Such distance must depend on the depth of the glacier, the rate of its motion, and the activity of the destructive agencies to which it is exposed. It is of course widely different for glaciers of different magnitudes, but for those which are sufficiently large to be considered of the *first order*, it varies much less than might perhaps be expected, as appears from the following table. The glaciers specified are all of the first order in magnitude, except, perhaps, that of the Maladetta.

	Latitude.	Height of snow-line.	Names.	Height above the sea.	Ht above snow-line.	Name of glaciers.	Heig't of low'r end of glac'r.	Descent below sn'w-line
		feet.		feet.	feet.		feet.	feet.
Pyrenees,	42 30	9300	La Maladetta	11,300	2,000	Gl. de la Maladetta	7,600	1,700
Caucasus,	42 30	10,300	Kasbek	15,000	4,700	Desdaroki	6,400	3,900
The Alps,	45 50	9000	Mass of Mont Blanc	13,300	4,300	Gl. des Bois	3,700	5,300
			Mont Blanc	16,000	7,000	Gl. des Bossons ...	3,700	5,300
						Gl. de la Brenva ..	4,500	4,500
	45 30	8800	Mass of the Grindelwald Mountains.	Mean, 13,300	4,500	Gl. de Grindelwald	3,500	5,300
						Gl. d'Aletsch	4,500	4,300
						Gl. de l'Aar	6,150	2,650
Scandinavian Fjelds,	61 43	5500	Summit of Lodalskaabe	6,800	1,300	Gl. of Lodalskaabe	1,700	3,800
			Plateau of Justedal	6,000	500	Gl. of Nygaard ...	1,100	4,400
						Gl. of Berset	1,500	4,000

The Table is extracted from the memoir of M. Durocher, in the *Annales des Mines*, 4 sér. tom. xii, 1847.

It will be observed that the descent of the Aar glacier below the snow-line is considerably less than that of any other equally large glacier enumerated in the above table. This I conceive to be due to the very small inclination of the bed of that glacier towards its lower extremity. If we reject this example as anomalous, the mean descent of the remaining nine great glaciers below the snow-line is about 4500 feet.

There are also three glaciers in the Himalayas, from the extremities of which the Pindur, the Gori, and the Ganges issue. The heights of these sources have been incidentally given by obervers,* as being respectively 11,946, 11,543, and 13,500 feet. Taking Capt. Strachey's estimate of the height of the snow-line

* See Captain Strachey's Paper "On the Snow-line in the Himálaya," Journ. Asiatic Soc., Bengal, April, 1849; and Edinb. New Phil. Journ., vol. xlvii, 1849; and "On the Physical Geography of the Provinces of Kumáon and Garhwál," Journ. R. Geograph. Soc., 1851.

as 16,000 feet in that region, we have 4054, 4457, and 2500 feet for the descents of these glaciers below the snow-line. The two former are in very near accordance with the mean of the cases above given; the last more nearly accords with the smaller descents of the glacier of the Aar, and is probably due to a similar cause.

The glaciers which proceed from more limited spaces for the accumulation of snow and ice descend below the snow-line to distances much shorter than those above given.

2. *Height of the Snow-line, and Descent of Glaciers below it in the hypothetical cases of* § I.

The degree of cold requisite to produce glaciers on a mountain might obviously be caused by the elevation of the mountain. I shall, in the first place, suppose former glaciers in western Europe to have been due to this cause alone, and determine the general elevation of that region which would be necessary to produce such effects, rejecting the supposition, as altogether improbable, that each individual mountain which exhibits glacial phenomena was locally elevated independently of any corresponding elevation of the surrounding region. I shall then proceed to the hypothetical cases of the previous section.

24. The present mean annual temperature of the Alps may be taken at 55°·5 F. (§ 13, p. 77), or 23°·5 above the freezing temperature. The height of the snow-line is about 9000 feet, and that of the line of 32° F. about 7000 feet, which gives a decrease of 1° F. for about 300 feet. If the surrounding region should be elevated several thousand feet together with the Alps, we may take the decrease of temperature for 1° from the level of the sea for about 400 feet (§ 20, p. 249). This would give the height of the line of 32° above the level of the sea, after the elevation, equal to about 9300 feet; and assuming the height of the snow-line to exceed this, as at present, by 2000 feet, the height of that line would be 11,300 feet. It is probable that the glaciers would not in this case descend quite so far below this line as at present. Suppose them to descend 4300 feet below it; the height of their lower extremities would then be about 7000 feet above the level of the sea. Consequently the glaciers would descend into the level of the lake of Geneva, provided the elevation of the region placed that lake 7000 feet above the sea, or about 6000 feet above its present level.

Hence, if blocks on the Jura have been transported from the Alps by the agency of ice, the Alps must, according to our present hypothesis, have been at least 6000 feet higher than at present, supposing the surrounding region to some extent to have been elevated at the same time.

The present mean annual temperature of Snowdon is about 49°·5 F., or 17°·5 above the freezing temperature. Assuming the general elevation of western Europe, Snowdon would stand on a wide elevated table-land, and we may take the decrease of temperature at 1° F. for about 450 feet.* This would give the height of the line of 32° equal to rather more than 7800 feet, and, supposing the snow-line 2200 feet higher, we have 10,000 feet for the height of this latter line. Now to produce glaciers of considerable magnitude on Snowdon, its summit must probably rise some 1000 feet above the snow-line, or to the height of 11,000 feet. Hence the whole region must be elevated between 7000 and 8000 feet above its present level. The glaciers might then be expected to descend to the table-land at the foot of the Snowdonian mountains, *i. e.* about 2000 feet below the snow-line. Further descent to any extent would be prevented by the comparatively horizontal surface of the immediate foot of the mountains.

In higher latitudes the required elevation would be smaller; but speaking generally, in order that glaciers should exist on our present mountains of sufficient magnitude to descend down to their present bases, in consequence of a general elevation of western Europe, it would be necessary that that region should be raised into an elevated range from the polar circle to the south of the Alps, rising in some parts to the height of 10,000 or 12,000 feet.

25. I shall now take the case in which the old and new continents are supposed to be united by the conversion of the basin of the Atlantic into land. We should have, according to the estimate above given (§ 15, p. 80), the mean annual temperature of the Alps about 44°·5 F., or 11° lower than at the present time. The position of the line 32° F. would therefore be lowered by about 3500 feet, but the distance of the snow-line above it would be much increased by both the causes which appear chiefly to influence that distance. The oscillation of temperature from January to July, would be 61° F. instead of 34° as at present, and the quantity of snow falling during the year would doubtless be much diminished by the entire absence of sea in the surrounding region. It would seem probable that the position of the snow-line would be as much raised by these causes, as it would be lowered by the diminution of temperature. Moreover, it is probable, that the glaciers would not descend so far below the snow-line as at present, on account of the diminution of their mass, arising from the diminished quantity of snow. I conceive it probable, therefore, that the Alpine glaciers would not descend, in the case now contemplated, to points less elevated

* I take this number greater than for the Alps, because the elevation of the surrounding region would in this case form a higher table-land than that immediately around the Alps.

than at present above the level of the sea. In such case it would be necessary to give to the Alpine region about the same additional elevation as in the former case (§ 24) in order that the glaciers should descend to the lake of Geneva.

The mean annual temperature of Snowdon would be nearly 30° F., and the isothermal of the mean annual temperature of 32° would pass through the mountains of the southwest of Ireland which present many indications of former glaciers. Along this isothermal, the line of 32° F. would coincide with the surface of the earth, and the height of the snow-line above it would be identical with the absolute height of that line, which would therefore be about 2500 feet, if the distance between these two lines should be the same as at present. For the reasons assigned, in the preceding paragraph, this distance, however, would undoubtedly be much greater than at present. The oscillation from winter to summer temperature would amount to no less than 73° 5′ F. (§ 15), whereas it is at present only 23°. The present distance, therefore, between the two lines in question being taken at about 2500 feet, it is probable, I think, that in the case now considered, it would not be less than two or three times that quantity. And this conclusion appears to be in accordance with the knowledge we possess of the Altai mountains in the northeast of Asia. Those mountains rise to the height of 9000 or 10,000 feet, and the mean annual temperature is under 32° F.; and yet, as I am assured by that distinguished traveller, M. de Tchihatcheff, there are no glaciers upon them of any magnitude, a sufficient proof that the snow-line cannot in all probability be lower than the above estimate.

In proceeding farther to the north, the snow-line would probably meet the level of the sea about the latitude of the northern part of Scotland. In all higher latitudes the surface of the earth would be covered with perpetual snow.

It follows, then, that if the Atlantic were converted into dry land, it would still be necessary, in order to obtain glaciers to the extent required by observed phenomena, that the western part of Europe should be elevated into a range extending nearly from the 40th to the 60th parallel of latitude, and higher than the present surface by some 4000 or 5000 feet.

26. I now proceed to that which I consider by far the most important of our hypothetical cases,—that in which we assume the absence of the Gulf-stream and the submergence of a large portion of northern and central Europe beneath the ocean. There is no difficulty in this case in accounting for the existence of glaciers in the northern parts of Scotland and in more northern latitudes; but it is necessary to consider carefully how far the conditions of their existence in the more southern latitudes in which traces of glacial phenomena are observed, could be fulfilled. I will first consider the Snowdonian region.

Let us suppose Snowdon and the surrounding country lowered 500 feet below its present level. If the whole of Europe were depressed to the same amount, a large portion of it would be submerged beneath the ocean; but we are at liberty to suppose any part of it depressed to a greater amount, if necessary to produce the more complete submergence here assumed. I have estimated the most probable mean annual temperature of Snowdon at 39° or 40° F., in the absence of the Gulf-stream (§ 13, p. 77) and of any cold current from the north; and I have also shown that it would be little altered by the submergence of Europe beneath the sea (§ 18, p. 85). This would give the height of the line of 32° F. equal to at least 2200 feet, or about 800 feet below the summit of Snowdon in its depressed position. In estimating the position of the snow-line with reference to the line of 32° F., it must be recollected that the region about Snowdon would form a group of small islands in the midst of an extensive ocean, and would so far be under conditions favorable for producing a moist climate and a low position of the snow-line relatively to the line of 32° F. I have already (§ 18) referred to Iceland and the island of South Georgia as furnishing cases similar in conditions to this hypothetical case of Snowdon. Their insular positions and mean annual temperatures are nearly the same as in that case. The difference of summer and winter temperature, however, would be greater for Snowdon than for either of the other cases, being about 14° for S. Georgia, 20° for Iceland, and between 30° and 40° for Snowdon. These considerations would lead us to conclude that the height of the snow-line, with reference to the line of 32° F., would be somewhat higher on Snowdon than in the other two cases. The height of Snæfell Jokul, on the northwest coast of Iceland, is, according to Makenzie, 4558 feet, and that of the snow-line upon it 2734 feet, as measured by Sir J. T. Stanley. The mean annual temperature there is about 38°, and consequently the height of the line of 32° must be about 2000 feet, upwards of 700 feet below the snow-line. On the south coast of Iceland the mean annual temperature is about 40°, and the height of the line of 32°, consequently, less than 3000 feet. The height of Eyafialla Jokul is about 5500 feet, and the height of the snow-line is probably much the same as at Snæfell. The glaciers there are stated to descend nearly to the level of the sea.

I have estimated the mean annual temperature of the island of S. Georgia at 38°. Consequently, the line of 32° will be at about the elevation of 2000 feet. It is very desirable that more accurate observations should be made on the height of the snow-line in that island than, I believe, have hitherto been obtained. The vague assertion that the snow-line there descends to the level of the ocean, has probably arisen from confounding that

line with the level to which the glaciers descend. All we seem to know is, that glaciers descend to the margin of the sea; but before we can reason conclusively on this, as a case analogous to that of Snowdon or of other mountains in our own islands, it is necessary to know more than I have at present been able to ascertain, respecting the height and configuration of the mountains from which the glaciers descend. Mr. Darwin in his Journal quotes Cook's description of the island, but it contains no accurate information on the points in question, although it would lead to the inference that the snow-line must be considerably below the line of 32° F.

It would seem very possible then, that the snow-line on Snowdon in the present hypothetical case might not be higher than the line of 32° F., the height of which is above estimated at 2200 feet. Glaciers might thus descend from a snow-line little more than 2000 feet high to the level of the sea.

27. If, in addition to the hypothesis of the absence of the Gulf-stream, we adopt that of a cold current from the north, sweeping over the submerged portions of northern and western Europe, we shall have an additional cause which might probably lower the mean annual temperature of Snowdon and the neighboring region by 3° or 4° below that above assumed. Such a current would also tend to equalize the summer and winter temperatures, since its effect would there be principally or entirely produced on the summer temperature, which might possibly be lowered 6° or 8°. The snow-line would thus be brought at least 1000 or 1200 feet lower than above supposed. This would be sufficient to account for glaciers descending to the sea, not only on Snowdon, but also on the lower mountains of the west of Ireland.

28. Conclusions, but somewhat vague, have been drawn respecting the former possible existence of glaciers in western Europe, from the actual existence of glaciers descending to nearly the sea-level in South America, in comparatively low latitudes. But in this comparison the relative heights of the mountains in the two regions has been frequently, I think, overlooked. In the case we have been discussing, the mean annual temperatures in corresponding latitudes in the two hemispheres would be almost exactly the same, and probably the quantity of moisture in the atmosphere and the quantity of snow in similar positions might be much the same; but the greater extent of land which must have existed in the northern hemisphere, as compared with the southern, in the more recent geological periods, must have rendered the summer temperature greater in the northern than in the southern hemisphere, and consequently the snow-line and, *cæteris paribus*, the lower extremities of the glaciers somewhat higher in the former than the latter region. The great distinc-

tion, however, between the western coast of South America and that of Europe consists in the great difference in the heights of their mountains. A glacier is described by Mr. Darwin* as descending to the sea-level in the Gulf of Penas, on the west coast of South America, in latitude 46° 40′. According to Dove's map, we have for that place—

July temperature, ...	40° F.
January temperature, . . .	50
Mean annual temperature, . . .	45

Hence the height of the line of 32° must be about 4500 feet. The difference between the January and July temperatures is only 10°, the latter being considerably reduced by the cold current passing round Cape Horn. This, with the proximity of the Pacific, is highly favorable to a low position of the snow-line. It may probably lie near the line of 32°, or even considerably lower, in which case the glacier must descend between 4000 and 5000 feet below it. This coincides with the distances to which almost all glaciers of the first order descend below the snow-line (§ 23, p. 252) and presents nothing anomalous. It is described as a very large glacier, descending from a lofty mountain, which rises, undoubtedly, many thousand feet above the snow-line. It is in this respect that the analogy between the glaciers of South America and those which may have formerly existed on such mountains as those of the British Islands entirely fails. With the same climatal conditions, we might have glaciers descending to the sea-level in the one case, without a trace of glaciers in the other.

29. I shall now discuss the case of the Alps. Adopting the hypothesis of a current from the north, it is manifest that such a current would, as already remarked, tend much to equalize the temperature from the latitude of Snowdon to that of the Alps in the present region of western Europe, precisely as the Gulf-stream now equalizes in so remarkable a degree the temperatures of different latitudes in a considerable portion of its course in the northern ocean. If we assume its effect on the mean annual temperature of the Alpine region to be 8° or 9°, instead of 3° or 4°, as in the Snowdonian region, we shall probably not overestimate its influence. The mean annual temperature would be thus reduced to about 45°. The height of the line of 32° would then be about 5000 feet. The difference of summer and winter temperatures would be considerably less than at present, and the position would approximate much nearer to the character of an insular one. Both these circumstances would be favorable to a lower position of the snow-line with reference to the line of 32°, than at present, and the latter also to the production of snow.

* Darwin's Journal, p. 284.

Under such circumstances glaciers might descend to the sea-level, where the configuration of the mountains should be sufficiently favorable to their descent, and supposing the sea to stand at such a relative height as to reach the bases of the mountains. That this was the case, I have little doubt; for with the conviction that an enormous erratic block like the *pierre à bot*, above Neufchatel, must have been transported across the valley of Switzerland by floating ice, I think it most probable that the whole Alpine region was, at the glacial period, 2000 or 3000 feet at least lower than its present level; so that the sea might not only extend to the base of the Alpine range, but might also penetrate into many of its lower valleys.

Thus it appears from this investigation, that the same conditions which would produce glaciers on our Welsh and Irish mountains, descending to the level of the sea from a snow-line from 1000 to 1500 feet above that level, might also produce similar phenomena in the Alps with a snow-line 5000 or 6000 feet above the sea. In more northerly regions there would, of course, be no difficulty in accounting for the existence of similar glaciers.

(*To be continued.*)

[Note.—The Map which we have added to this volume in illustration of Prof. Hopkins's paper, is a copy of one of the isothermal charts of Dove—that for January; except that we have made it throughout a winter chart by substituting for the January lines south of the equator the July lines, July being midwinter in the Southern hemisphere. The positions over Europe and the Atlantic of the lines of 32°, 23° and 14° in Prof. Hopkins's hypothetical cases, are shown by interrupted lines connecting Dove's lines (the dotted lines) of the same name.—Eds.]

Art. XXXI.—*Brief Characters of some New Genera and Species of Nyctaginaceæ, principally collected in Texas and New Mexico*, by Charles Wright, Esq., under the direction of Col. J. D. Graham, U. S. Topogr. Engineers, late Chief of the Scientific Corps of the Mexican Boundary Commission; by Asa Gray, M.D.

ACLEISANTHES, Nov. Gen.

Involucrum nullum. Perigonium tubulosum vel tubæforme, limbo patulo 5-angulato. Stamina sæpius 5, inclusa. Stylus mox exsertus: stigma peltatum læve. Fructus ovoideus vel cylindraceus, 5–10-costatus. Embryo conduplicatus, albumen farinosum includens; cotyledone interiori minore.—Herbæ radicibus tuberosis; caulibus decumbentibus vel diffusis; foliis op-

positis petiolatis; floribus albis vel albidis solitariis (raro geminatis) terminalibus vel pseudo-axillaribus subsessilibus bracteolis 2 subulatis parvis subtensis.

A genus principally distinguished from Mirabilis by the want of an involucre; whence the name. From Nyctaginia, with which Choisy confounded one species, it abundantly differs in its solitary or subsolitary and sessile flowers, destitute of an involucre, unless the pair of minute subtending bracts be so called, and in the included filaments. In this, as in most Nyctagineous genera, a portion of the flowers, especially the earlier ones, are precociously fertilized in the bud, while the perigonium is yet small; when the latter, being arrested in its development by the growth of the fructifying ovary, never expands.

1. Acleisanthes crassifolia (sp. nov.): scabro-puberula; caulibus decumbentibus; foliis crasso-coriaceis ovatis basi rotundatis mucronatis: tubo perigonii limbo ter quaterve longiore; fructu ovoideo vix costato.—High prairies of San Felipe Creek, W. Texas; July, 1849. (No. 599, coll. *Wright.*) Tube of the expanded flower, one and a half to two inches long; in the precociously fructified flowers much shorter.

2. Acleisanthes longiflora (sp. nov.): glabra; caulibus basi suffruticosis divaricato-ramosissimis deltoideo-ovatis summisve rhomboideo-lanceolatis acuminatis margine undulatis; tubo perigonii prælongo gracili (5–6-pollicari); fructu cylindraceo 5-angulato.—Valley of the Limpio; and near San Antonio, Texas. (*Wright*, No. 599.) Stony hills of the Pecos, May. (*Wright*, No. 1704.) Also collected in Texas by *Prof. Riddell* and by *Mr. Lindheimer;* and in Northern Mexico by *Dr. Gregg.*—Leaves variable in shape, about an inch long. I have seen little mature fruit, and no precociously fructified flowers.

3. Acleisanthes Berlandieri: glabra, diffusa; foliis cordatis reniformibus ovatisve obtusis vel acutis parvis; tubo perigonii limbo duplo triplove longiore.—Nyctaginia obtusa, *Choisy in DC. Prodr.* 13, *p.* 429.—Corpus Christi, and on the Rio Grande, Texas. Between the Rio Frio and the Nueces, Texas, *Berlandier.* Near Monterey and Matamoras, *Gregg.*—Leaves a third to two thirds of an inch in length, not including the slender petiole, variable in shape. Flowers white, tinged with purple in fading, as in all the species. Fruit unknown.—Choisy describes the leaves of his Nyctaginia obtusa as "cuneate-oblong, obtuse at both ends;" but a rude sketch which I made from the original specimen, in the Candollean herbarium, exhibits them as rounded-cordate, or somewhat reniform. I doubt not, therefore, that it is the plant here characterized, although other points in the character are more or less at variance with my incomplete specimens. No. 1705 of Wright's collection, from hills between the San Fe-

lipe and the Pecos, may belong to this species; but it is as likely to be a depauperate state of the preceding. These specimens have no developed flowers.

4. ACLEISANTHES ANISOPHYLLA (sp. nov.): glabella, humifusa; foliis ovalibus seu ovatis basi obliquis vel oblique subcordatis in eodem pari valde inæqualibus, altero nunc fere abortivo; tubo perigonii evoluti limbo pluries longiore; fructu 10-costato.—Prairies of Turkey Creek and Elm Creek, W. Texas, May. (*Wright*, No. 598, 1706.)—Leaves somewhat resembling those of Allionia incarnata, especially the glabrous variety, but much more unequal; the larger one of each pair an inch or an inch and a half long, on a petiole of three or four lines in length; while the smaller one is never longer than the petiole of its fellow, in the lowest cauline, and the latest rameal pairs sometimes obsolete or nearly so. The full-grown flowers are an inch and a half to two inches in length; the precociously fertilized ones much smaller. I have seen the fruit only from the latter, and that not fully formed: it is fusiform, or ovoid-oblong, and only two lines in length.

PENTACROPHYS, Nov. Gen.

Involucrum e bracteolis 3 subulatis, florem solitarium subsessilem fulcrans. Perigonium (perfectum ignotum,) florum in alabastro præcoque fecundatorum tubulosum, breve. Stamina 2. Stigma peltatum læve. Fructus cylindricus, truncatus, 5-costatus, costis crassis suberosis apice glandula magna umbonatis. Embryo conduplicatus, albumen farinosum includens; cotyledone interiori minore. Herba humilis, e radice lignescente multicaulis, diffusa, viscoso-pubens, scabrida; foliis oppositis petiolatis ovalibus; floribus axillaribus et terminalibus parvulis.

PENTACROPHYS WRIGHTII.—Stony prairies at the Big Bend of the San Pedro River, and between the Pecos and the Limpio, on the route between Texas and El Paso; May, June, (*Wright*, No. 1713.) Cultivated in the Cambridge Botanic Garden, it produced a succession of flower-buds during the summer and autumn, all of which were precociously fertilized, but not a single flower attained its full development. The indigenous specimens also bore abundance of fruit, the younger surmounted by the undeveloped perigonium, but no expanded flowers were seen. From analogy, however, such may be expected to occur. In one instance, two flowers were detected in the same involucre, if such the three small bractlets may be termed. The fruit is three or four lines long; its very thick ribs leave only narrow grooves between them. The superficial tissue of these ribs abounds in tubular cells, containing a spirally coiled thread, which is usually disengaged upon the application of moisture. Dr. Torrey has remarked to me that this structure is found in most Nyctaginaceæ

except Pisonia. The position of this genus is evidently between the preceding and the following.

SELINOCARPUS, Nov. Gen.

Involucrum nullum. Perigonum (perfectum) cyathiforme, vel infundibulari-tubulosum, limbo 5-angulari. Stamina 2 seu 5, mox exserta. Stylus filiformis: stigma peltatum læve. Fructus 5-alatus (vel abortu 3–4-alatus), alis scariosis aveniis. Embryo conduplicatus, albumen farinosum includens; cotyledone interiori minore. Herbæ humiles (vel suffruticuli), e radice tuberosa seu lignescente multicaules; foliis oppositis subinæqualibus alternisve petiolatis; floribus terminalibus vel pseudo-axillaribus sæpius geminatis vel fasciculatis; bracteolis 1–3 subulatis minimis seu abortivis.

The fruit of these plants much resembles that of certain Umbelliferæ, such as Cymopterus and Selinum (whence the name). Much of it is produced from flowers precociously fertilized in the bud, as in all the allied genera. Besides the two subjoined species, there is one with suffruticose stems in the late Dr. Gregg's Mexican collection; but my specimen is too imperfect for description.

1. Selinocarpus diffusus (sp. nov.): pube hirtella subviscosa scaber; caulibus ramosissimis depressis vel patenti-diffusis; foliis ovatis seu ovato-oblongis obtusis; floribus sæpius geminatis subsessilibus; tubo perigonii evoluti elongato (sesquipollicari); staminibus 5.—Rocky hills and valleys from the Pecos to the Limpio; May, June. (*Wright*, No. 1708.) In foliage and habit the plant is not unlike Allionia incarnata, but it is more branched and tufted. The flowers, when geminate as well as when solitary, are each subtended by 2 or 3 small and subulate bractlets, which therefore do not properly represent an involucre. The unopened perigonium of the precociously fructified flowers, which usually persists until the fruit is ripe, does not exceed a line in length; while the fully developed flowers are an inch and a half long. The fruit from the two kinds of flowers is just the same: it is three lines long, broadly oval in circumscription, including the wings, which are as wide as the body. These are entirely veinless, and almost wholly consist of parallel, very long and filiform cells, which, on being torn asunder in water, emit attenuated gelatinous threads.

2. Selinocarpus chenopodioides (sp. nov.): pulverulento-puberulus, subcinereus; caule erecto ramoso; foliis late ovatis nunc subcordatis repandis longe petiolatis demum glabratis; floribus cymuloso-fasciculatis pedicellatis parvis; perigonio etiam evoluto brevi, cyathiformi, tubo subnullo; staminibus 2.—Valleys from Providence Creek to the Rio Grande, New Mexico; also near

Lake Santa Maria, Chihuahua; April, June. (*Wright*, No. 1707.) Stems nearly a foot high. Leaves often alternate, twice the size of those of the preceding species, whitened, at least when young, with an apparently farinose fine pubescence, somewhat as in a Chenopodium. Flowers pretty numerous in terminal and alar, cymulose clusters. Bractlets minute and solitary, or none. The expanded perigonium barely two lines in length. Fruit nearly as in S. diffusus, but slightly obovate in outline. Embryo as in Pentacrophys and Acleisanthes.

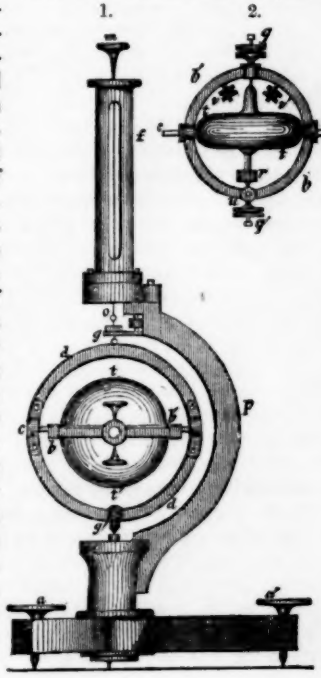
(*To be continued.*)

SCIENTIFIC INTELLIGENCE.

I. Correspondence.

Correspondence of M. J. Nicklès, dated Paris, January 9, 1853.

Foucault's New Method of exhibiting by experiment the Rotation of the Earth.—Among the subjects brought before the Academy of Sciences within the two years past, none has excited more general interest than certain new properties of revolving bodies and the relations of these properties to the rotation of the earth. Several reclamations of priority have followed the first announcement of the discovery in September of 1851; M. Person, M. Foucault, M. Sire, M. Hamman and M. Lamarle, were all occupied with the subject and had arrived at interesting results. Leaving unsettled the question of justice to each of these physicists, we give a description of a new instrument constructed by M. Foucault, by which he establishes the property first announced by him before he knew of his rivals.—t, t', (fig. 1,) is a torus of bronze, poised on its axis by means of screws adapted to adjust the center of gravity so as to make it coincide exactly with the center of its figure. The axis of the torus is of tempered steel, ending in two conical points, retained, by slight friction, by the extremities of two screws, q, q', (fig. 2,) which act in place of pivot-holes. On the axis of the circle there is a pinion, r, which can interlock with the teeth of a wheel intended to give the circle a rapid revolving



motion, equal to 150 turns a second. It is unnecessary to describe the apparatus for producing this motion, as any apparatus will answer that can be adapted to the pinion and will give the requisite rapidity. The center of the torus is occupied by a thin disk which carries a plate of glass with parallel surfaces or a metallic mirror, by means of which, the exact plane of rotation of the moving object can be observed through the reflection of a distant mark. The torus and its axis are supported by a cylindrical ring b, b', (figs. 1 and 2,) one of the diameters of which is occupied by the axis of the torus. In this ring are the conical pivot-holes, q, q', in which the two points of the axle of the torus can play and be more or less restrained in their movement. Above the screws with pivot-holes, the ring carries the vertical screws, u, u', which in connection with the other horizontal screws, v, v', serve to adjust the whole in equilibrium when supported on the knife blades of tempered steel, c, c', which are on the exterior part of the ring at the extremities of the diameter perpendicular to that which contains the axis of rotation of the circle. These knife edges are made to rest on two agate plates on a third ring, d, d', (fig. 1,) the exterior member of the system.

The apparatus is brought into exact equilibrium, with the knife blades perfectly level whatever position be given the torus in its revolution; the ring which carries it always remaining horizontal, so that, like the beam of a delicate balance, the slightest addition on one side or the other will cause it immediately to dip accordingly. The exterior ring is so placed that the agate plates are in its horizontal diameter while its vertical diameter contains the arrangement for suspension. This arrangement consists of a hook o, on the upper side of the ring for attaching a thread of untwisted silk; this silk thread is protected by a vertical tube (f, fig. 1) and is attached to a thumbscrew m, which serves to raise or let down the ring a little, as may be needed.

The piece which carries the hook passes through a double piece, g, whose upper part acts in fixing the ring in its position; but there is no friction as the object is only to prevent a pendulum movement in the ring. On the lower side, this ring carries a conical point, g', which moves in a pivot-hole without touching, the object of which like the part g, is simply to prevent a swinging motion.

This apparatus is supported by a semicircle, p, having a foot with thumbscrews, a, a', for making it horizontal, so as to place the thread and the large ring in a perfectly vertical plane.

The torus and its ring may be easily taken out from the outer circle to be adjusted to the apparatus employed for setting the torus in rotation; at the moment this rotation is obtained, the whole system is replaced in the outer circle, when the phenomena due to the fixedness of the plan of rotation soon become apparent.

For the purpose of measuring the *apparent* motion of the great circle (or rather the *actual* motion of the observer) a large ring graduated to degrees, minutes, etc., is made to surround the apparatus, at a level with the knife blades; and there is a microscope having a fixed wire adjusted to the eye-piece, for reading the smallest divisions. In this way the angular movement of the circle is easily shown to be proportional to the sine of the latitude.

If in place of putting the knife blades on the agate plates, we insert the points of the screws, q, q', which carry the axis of the torus, by which all movement of inclination in the inner circle is prevented, we perceive at once a movement of orientation in the apparatus by which the great circle places itself with the plane of rotation of the torus in the prime vertical, while the axis of the torus is arrested in the plane of the meridian of the place. But if the inner circle is replaced on its knife edges, and the outer is then fixed in the direction of the prime vertical by means of the screw q', while the axis of the torus is on the meridian, we see at once the inner circle become inclined, and finally parallel to the axis of the diurnal rotation of the earth, so that the direction of the movement of the torus is the same with that of the diurnal rotation.

This apparatus M. Foucault calls a *gyroscope*, and by its aid we may find the pole, and the east and west points, determine the latitude of a place, and study the rapidity of the earth's motions, without recourse either to astronomical observations, the magnetic needle, or a pendulum. The apparatus has been admirably constructed by M. Froment. Other capable mechanicians had given it up; but it proved mere play to this distinguished artist who has so largely extended the limits of precision in philosophical instruments. We shall more than once entertain our readers with the apparatus, and especially, the electro-magnetic machines of M. Froment. Everything connected with electricity is manufactured in his establishment, and it is a treat to gain access to his private apartments where there are all kinds of electro-magnetic machines, and among them some whose electro-magnets make 12,000 inversions per minute.

Influence on Astronomical Observatories of vibrations produced by vehicles passing on roads, and other causes.—The Paris Observatory is surrounded by roads in constant use, day and night. A railroad (the line to Sceaux) is near by. The vibrations produced by vehicles on these roads, have for a long time been observed, and they have interfered with their observations, especially those made with the aid of reflection from a mercury horizon. These difficulties, which have been felt by all astronomers who have observed in circumstances like those of Paris, came under the consideration at the same time of M. Mauvais, of the Paris Observatory, and M. Séguin, Sr. The latter, the illustrious inventor of tubular boilers, is now retired from his honorable labors, in a small but elegant observatory constructed at the centre of the buildings of the old abbey of Fontenay, near Montbard, and close to a paper manufactory, the movement of whose cylinders caused his artificial horizons of mercury to vibrate, and produced oscillation in the star reflected in the field of the telescope. While these astronomers were planning, unbeknown to one another, a method of overcoming these difficulties, M. Mauvais happened to pass by Montbard, and meeting M. Séguin, mentioned to him his project; and since then they have been united in their endeavors, and have hit upon an extremely simple means of protecting the mercury from external vibrations. The method is to take a strap of vulcanized caoutchouc, fold it double and fix in the fold, that is, at the middle of the band, the stand which supports the mercurial horizon; then attach a cord to each end of the strap and

fasten it to the ceiling. It is essential to success that the mercury should not be so heavy as to injure the elasticity of the strap, or subject it to its maximum of tension. Messrs. Seguin and Mauvais have thus secured good results with the caoutchouc band; they have found that in order to extinguish the vibrations indicated, elasticity by *traction* is preferable to elasticity by *pressure*. The solution of this difficulty will be welcomed by astronomers, and especially by M. Airy, who after having arranged a thick bed of sand in one of the halls of the Greenwich Observatory, for his artificial horizon, still found that it had not the steadiness required by his zenith reflection telescope, an instrument from which he had expected great results.

Tangent Compass.—The accuracy of the indications afforded by the tangent compass has of late been more than once suspected, and quite recently, this instrument has been critically examined by M. Jacobi, who has extended his researches to nearly all the instruments used for measuring the intensity of currents.

M. Despretz has treated this subject profoundly by a series of experiments which the limits of this communication will not allow me to report. The fundamental fact established is that the tangents of the deviations are not necessarily proportional to the intensity of the current, and that they can be considered proportional only when the great circle in which the current passes has a diameter of a meter, and the length of the needle is not under 3 centimeters.

Such large needles will in fact have little sensitiveness; but they may be made as sensitive as small needles, by substituting, for the plate of the great circle, four large wires, 5 to 8 millimetres in section, insulated from one another by being wound with silk.

The tangents of the deviations of this instrument represent the intensity of the currents, and we have thus a true *proportional rheometer*.

If we replace the four large wires by a bundle of twelve to twenty wires of smaller size, (for example, three to four millimeters,) we shall have *proportional rheoscopes*, sufficiently sensitive for measuring the intensity of the feeblest currents. In order that the delicacy of the divided circle should correspond with the precision of the apparatus, it is necessary that the circle should be about 30 centimeters in diameter.

These rheometers and rheoscopes may also be used for graduating ordinary rheometers and rheoscopes.

The formula used by Despretz for the calculation of his results, and which accords with experience, is not the ordinary formula,

$$I = T \tan \theta$$

in which T represents the intensity of terrestrial magnetism, but the more complex formula,

$$I = (1 + 3a^2) \tan \theta - \frac{15a^2}{8} \sin 2\theta$$

which is founded on the theory of Ampere. In this formula, I represents the intensity of the current; θ, the deviation which it impresses on the needle; a, the relation between the semi-distance of the poles of the needle and the radius of the circle of the current.

Self-registering Compass.—M. Deleuil has presented to the Academy a self-registering compass of his construction. Its object is to reg-

ister the changes of direction in a vessel for every 3 minutes during the 24 hours. The marking is made on a compass-card; and it enables the captain to control with certainty the direction followed by his ship, and overlook most effectively the maneuvers of the steersman and pilot.

This self-register consists of 3 principal parts; 1, a clock-movement placed at the center of the apparatus, for causing the point or pivot carrying the needles, to move up and down at regular intervals; 2, an endless screw, furnished with a nut carrying the point for piercing the paper; 3, the compass-card made of 3 needles fixed to a sheet of mica, a material as little hygrometric as possible. The mica is covered with a disk of velvet firmly glued to it by means of strong glue, and whose tissue has been saturated by a kind of glue that is soft when cold; on cooling, the glue has an even surface pierced with an infinity of pores into which the point will readily penetrate after having pierced the paper compass-card. Owing to this addition, the process of puncturing does not stop the movement of the needle, a principle essential to the success of any method of self-registering.

When the needle is fixed towards the north, the axis or diametral line of the compass-card is placed in the line of the axis of the ship, and the punctures, made every three minutes, will indicate the deviation of this axis with reference to the magnetic needle: the succession of points, or the nearly continuous line which they trace, shows to the eye the course of the route.

On Extinguishing Fires by Steam.—After the burning of the Amazon, and Henry Clay, M. Dujardin, of Lille, recalled the fact that in 1837 he proposed to employ steam for extinguishing fires; as was also mentioned by M. Fourneyron, soon after the disaster of the Amazon. I will add that the process proposed by M. Dujardin has been tried with full success during a fire that occurred in the Galvanoplastic work-shops of MM. Christoffe, at Paris. The fire had already made great progress, and threatened a complete destruction of the buildings before aid could be had. At this crisis, some one present suggested the idea of opening the valve of the boiler which feeds the engine, and immediately the steam penetrated through the work-shops, the fire was seen to diminish, and soon was reduced to so trifling an extent that it was easily mastered when aid arrived.

This fact cannot have too great publicity; and it is especially important that manufacturers, captains of vessels, and superintendents of work-shops should be familiar with it.

On Bread.—It is generally admitted that fresh bread differs from that which is stale by containing a larger proportion of water, the change after leaving the furnace being attributed to a gradual drying. It is consequently argued that bread contains the most nutriment in a given weight, when stale.

M. Boussingault has recently shown that the difference between the fresh and stale condition is not due to a diminution of the water, but to a peculiar molecular condition which takes place on cooling, and which continues as long as the temperature remains below a certain limit. M. Thenard explains this transformation by considering the bread a hydrate which heat softens, and a low temperature hardens, or renders

less soft. The same effect takes place actually with many substances, as grains, resins, wax, caoutchouc, gutta percha: it is simply a softening by heat, and hardening by cold.

Bread quite stale may be rendered tender after exposure in an oven, heated to 70° C. (158° F.) M. Boussingault has shown that the softening may be produced at a temperature between 50° and 60° C., and that this transformation from soft to stale bread, and the reverse, may take place a number of times. The loss of water is of very small amount. M. Boussingault has observed that bread will become stale even when kept in an atmosphere saturated with moisture.

Chemical Papers read before the Academy of Sciences.—Many communications have been made to the Academy of Sciences since my last communication. Several of them have especially a theoretical bearing and cannot be analyzed in this place. Of this nature is a memoir on *the uric chlorosulphalic and percarbonic compounds*, by M. Laurent, whose impaired health now for two years has weakened his physical vigor, but without diminishing his relish for science, or his passion for research. Another paper is on *an application of the theory of achromatism to the compensation of the angular movements which the rotatory power impresses on the planes of polarization of luminous rays of unequal refrangibility*, by M. Biot, who is always young, and always active, in spite of his 80 years. There are also notes by M. Babinet, and M. Zantedeschi, on the longitudinal lines of the spectrum, etc. etc.

Electrical Machines.—The common electrical machine, so much neglected since it has been dethroned by the pile, still receives from time to time some little improvement. It will be remembered that a means of avoiding the influence of atmospheric humidity, by covering with a thin layer of tallow the glass supports of the conductors, was introduced by M. Munch of Strasburg, a physicist who invented a pile that bears his name, the *pile of Munch*.

Under the hands of M. Provenzali of Rome, the electrical machine is in the way of new progress. This physicist has found that by covering a part of the conductor of an ordinary electrical machine with a thin sheet of gutta percha, the sparks that may be drawn from the part thus covered exceed greatly in length what are afforded by the part uncovered. It appears that this effect depends on the obstacle which the insulating sheet offers to the dispersion of the electricity, which dispersion tends to take place from the asperities of the surface of the conductor, and which discharge in part at a distance this same conductor, whenever it is approached with a non-insulated conductor for drawing the spark. M. Provenzali proposes to cover the whole conductor of the machine in this way, to see if it will not protect it from the action of moist air and give always a considerable quantity of electric fluid.

In order to obtain the largest sparks, it is necessary to have the insulating sheet strongly electrized.

Manufacture of Paper.—It is well known that paper which is very white when first made, often becomes yellow some time after being used. The yellow color is not always uniform, but often comes out in spots more or less large of a circular outline, and a rusty tint. In some Paris manufactories, this defect (which is incorrectly attributed to an alteration of the fibre) is remedied in a simple manner, and as the

process of discoloration may not be commonly used in America, judging from some paper I have seen, I make a brief mention of the subject.

The researches were made here by a manufacturer who conbines in a high degree science and technology. M. Gélis recognized at first that the change of color was not due to any alteration in the ligneous fibre, and was owing to iron. But what the source of the iron? and how is it introduced? An examination of the manufacture, through its processes, shows that there is less iron in the pulp than in the paper made from it. The origin of the iron is hence not in the preparation of the pulp, but it must be attributed to the drying cylinders of steel under which it is passed while yet moist. The chlorine contained in the paste, and which it is very difficult wholly to remove by the washish process, becomes suddenly vaporized under the heated cylinders, attacks these cylinders, forms the protochlorid (Fe Cl) which thence impregnates the paper. Colorless itself, this chlorid gradually absorbs oxygen on exposure to the air, and thus the coloration takes place.

It is therefore not a remedy against iron but against chlorine that is required. The hyposulphite of soda is the simple antidote, and a very small quantity suffices to eliminate a large quantity of chlorine, since one equivalent of hyposulphurous acid requires four equivalents of oxygen, and therefore four equivalents of chlorine, to transform it into sulphuric acid.

For testing the complete removal of the chlorine, M. Gélis uses a liquor made of iodid of potassium and amidon (starch). This liquor becomes instantly blue if there is the least trace of chlorine.

On coloring Silk through the Food of the Silk-worms.—The interesting researches of M. Flourens relative to the coloring of the bones of animals through coloring matters taken with their food, are well known. These observations appear to have suggested an application of the principle which promises to make considerable stir in the silk interest. For some years, it has been attempted to color the silk by feeding the worms with organic coloring matters, but till recently the results have been very imperfect, the colors being uncertain and not uniform or bright. The problem has not been altogether solved; nevertheless a long step has been taken through the experiments of M. Roulin who has employed the *chica*, the red coloring matter used by the Indians of Orinoco for coloring their bodies. He sprinkles the leaves of the mulberry with this substance and has thus obtained beautiful cocoons of a rose red color, uniform in tint and apparently permanent.

Sulphate of Quinidine.—There has been recently distributed among commercial men a circular without date or signature and with no indication of its origin, announcing a large adulteration of the sulphate of quinine by a product little known, the *sulphate of quinidine.* It has excited much interest among dealers in quinine, and many methods have been suggested for detecting the presence of quinidine in sulphate of quinine.

This new organic base has been studied successively by MM. Henry and Delondre, Winckler, Howard, Zimmer, and Leers. MM. Henry and Delondre, its discoverers, considered it a hydrate of quinine. MM. Winckler and Leers examined a product made by M. Zimmer of Frankfort, and did not derive their quinidine from the incriminated Quin-

quinas; moreover they give no processes for obtaining the substance. M. Howard has announced that the base is abundantly contained in the *Quinquina cordifolia* of New Grenada, Bolivia, and Peru.

These chemists are not agreed in the composition and properties of the quinidine, and no one of them states the proportions between the quinine and quinidine contained in the suspected barks.

The most striking characteristics of the quinidine appear to be its constant crystallization, its very slight solubility in ether, the greater solubility of its sulphate in water compared with that of the sulphate of quinine.

MM. Bouquet and Schäuffelé have examined a New Grenada Quinquina imported largely into Europe; it comes from near Fusagasuya and is known under the name of *Quinquina caqueta.* Twelve kilogrammes of bark have afforded as pure quinine as that extracted from the *Q. Calysaya;* the sulphate has all the characters of the sulphate of quinine and shows no trace of quinidine.

In the black bittern which affords ordinarily the quinoidine, MM. Bouquet and Schäuffelé have found some grammes of crystallized products, resembling quinidine in some of their characters, but too different to be confounded with it. The total quantity of this crystallized product corresponded to 3 p. c. by weight of the sulphate of quinine obtained, in the treatment of the Quinquina essayed. It is easily understood that the works of a large manufacturer might produce these crystallized matters in small specimens, but not for adulterating the sulphate of quinine.

These authors conclude that the properties of the quinidine are so uncertain that it is prudent to wait for more investigation before admitting it among ascertained chemical bases.

Electric Telegraph.—In the Revue Encyclopedique of M. Moigno, the following line of electric telegraphs is said to be projected:—From London to Paris and Lyons, continued to Chambery and Turin, and to Genoa on the Mediterranean; the Sardinian government will unite Genoa with Spezia; a submarine company will continue it to Bastia across the small island of Gorgona; thence from Bastia to Cagliari in Sicily. A submarine wire uniting Sicily and the African coast can be established without great difficulty. This interval passed, a centre of telegraphic communications will be established at Tunis which the French government will extend to Bougie and Algiers, and the English government to Tripoli, Alexandria, Cairo and Suez.*

II. Chemisty and Physics.

1. *On the Epipolic Dispersion of Light.*—Stokes has published the results of an investigation of the very remarkable phenomena accompanying the action of certain substances upon light, first observed by Brewster, and subsequently more carefully examined by Herschel. Herschel observed that a weak solution of sulphate of quinine appears

* On account of the brief time between the receipt of the manuscript of M. Nicklès and the publication of this number we have to defer to our next one part of his paper treating of the standard meter, as it requires large illustrations.

colorless and transparent by transmitted light, but under certain aspects exhibits a blue color. The blue color was produced only throughout a thin stratum of fluid adjacent to the surface by which the light entered. The incident beam, after having passed through the stratum from which the blue light came, was not sensibly enfeebled or colored, but had lost the power of producing a blue color when admitted into a solution of sulphate of quinine. A ray so modified was termed by Herschel, *epipolized*. To explain this remarkable appearance, Stokes assumed that in the process of internal dispersion the refrangibility of light had been changed, and the following experiments place this mode of explanation beyond all doubt. A pure solar spectrum was formed in the usual manner, and a glass vessel containing a weak solution of sulphate of quinine placed in it. The rays belonging to the greater part of the visible spectrum passed freely through the liquid as if it had been water. But from a point about half-way between the fixed lines G and H to far *beyond* the visible extreme violet, the incident rays gave rise to light of a sky blue color which emanated in all directions from the portion of the fluid under the influence of the incident rays. The anterior surface of the blue space coincided of course with the inner surface of the glass in which the fluid was contained; the posterior surface marked the distance to which the incident rays were able to penetrate before they were absorbed. This distance was at first considerable, but decreased rapidly as the refrangibility of the incident rays increased, so that from a little beyond the extreme violet to the end of the blue space the color was reduced to an excessively thin stratum. The fixed lines belonging to the violet and the invisible region beyond, were beautifully represented by dark planes interrupting the blue space. When the eye was properly placed, these planes were projected into lines, and Professor Stokes indentified these with the fixed lines in Becquerel's map of the chemical spectrum. The blue dispersed light corresponding to any particular part of the incident spectrum, is not homogeneous, but consists of rays having a wide range of refrangibility, and not passing beyond the limits of refrangibility of the spectrum visible under ordinary circumstances. Stokes proposes to distinguish the two kinds of internal dispersion as true and false, the latter being merely the scattering of light produced by suspended particles and having nothing to do with the phenomenon of true internal dispersion. True internal dispersion proves to be almost universal in solutions made directly from different parts of vegetables. The tint of the dispersed light and the part of the spectrum at which dispersion begins, are different in different cases. In a decoction of madder in a solution of alum, the dispersion begins above the fixed line D and continues from thence far beyond the extreme violet; the dispersed light is yellow or yellowish orange. In studying these phenomena it is not necessary to use either fluids or clear solids, but washed papers produce, when properly examined, the same effect. Turmeric paper and paper washed with a solution of sulphate of quinine are highly sensitive; the extraordinary prolongation of the spectrum when received on turmeric paper had already been remarked by Herschel. A high degree of sensibility appears to be rare among inorganic compounds, but glass colored by peroxyd of uranium and solutions of the salts of this oxyd are remarkable exceptions.

There is one law relating to the change of refrangibility which appears to be quite universal, namely, that the refrangibility of light is *always lowered* by internal dispersion. The incident light being homogeneous, the dispersed light is found to be more or less composite. Its color depends upon its refrangibility, having no relation to the color of the incident light, or to the circumstance that the incident rays were visible or invisible. The dispersed light appears to emanate in all directions, as if the solid or fluid were self-luminous while under the influence of the incident rays. The effects produced on similar media lead to interesting information with respect to the nature of various flames. Thus the feeble flame of alcohol is extremely brilliant with regard to invisible rays of very high refrangibility. The flame of hydrogen appears to abound in rays of still higher refrangibility, while the light of the electric spark as tested by a weak solution of sulphate of quinine, is found to be very rich in invisible rays of excessively high refrangibility, such as would place them far beyond the limits of the maps hitherto made of the fixed lines in the chemical part of the solar spectrum. These rays are stopped by glass but transmitted through quartz. These circumstances render it probable that the phosphoro-genic rays of an electric spark are nothing more than rays of the same nature as those of light, but which are invisible and of very high refrangibility. If so, they ought to be stopped by a very small quantity of a substance known to absorb these rays with great energy. Accordingly, the author found that the rays from the electric spark which excite phosphorescence pass freely through water and quartz, but are stopped by adding to the water an excessively small quantity of sulphate of quinine.—*L. & E. Phil. Mag., November*, iv, 388.

[Note.—Prof. Stokes's discovery of the change in the refrangibility of rays of light, produced by certain media, is undoubtedly one of the finest contributions to this branch of science which has been made since the time of Malus. To the chemist in particular, this discovery opens a new and fertile field of investigation, furnishing a new *characteristic property*, the observation of which must henceforth, like the index of circular polarization, form part of every complete investigation of the properties of a given compound. The abstract of Prof. Stokes's paper in the L. & E. Phil. Mag., from which our own is taken partly verbatim, leaves us however in doubt as to many important particulars. It is not distinctly stated, for instance, whether the rays which are made visible by a solution of sulphate of quinine, are the true chemical rays or not, or whether these rays after the change in their refrangibility, are still capable of producing chemical changes, or whether the light *sifted through* the medium which produces internal dispersion is then capable of affecting a daguerreotype plate. If the true chemical rays can be converted into rays of pure light, then it is not impossible that by a still further diminution of refrangibility, rays of pure light can be converted into rays of heat.—W. G.]

2. *On Heliochromics.*—Niepce has communicated to the Academy a third memoir upon this subject, which contains many remarkable facts, and which appears to bring us nearer to the solution of the grand problem of photography—the production of images of objects in their natural colors. After having shown the possibility of reproducing col-

ored engravings upon metallic plates, as had already been accomplished by E. Becquerel, the author proceeded to the employment of the camera obscura, and succeeded in reproducing in their proper colors, pictures, flowers, natural and artificial, and images of dolls dressed in clothes of various colors. All the colors were in these cases, obtained on the metallic plate, while even silver and gold were depicted with their metallic lustre, and glass, alabaster and porcelain, with the lustre peculiar to each. The great difficulty consisted in obtaining all the colors at once, but the author found this possible, and often succeeded in the attempt, by choosing only bright colors of a clear tone, and the more brilliant of the dark colors. The most difficult color to obtain with the others, is the green of foliage, the green rays being almost as inert as the black ones; clear green colors, particularly if brilliant, as in glazed green paper, were, however, reproduced in a satisfactory manner. In all cases, the colors produced were transitory, and no method of permanently fixing them has yet been devised, but M. Niepce does not despair of accomplishing this, and has already obtained some results which appear to point out the path which is to lead to ultimate success.—*Comptes Rendus*, xxxv, 694.

3. *Fluorid of Antimony.*—Flückiger has studied the relations of antimony to fluorine and has found that but a single compound of these elements, namely, the terfluorid, exists. When an aqueous solution of fluohydric acid is poured upon oxyd of antimony, a solution immediately takes place accompanied by the evolution of great heat. By evaporating the acid solution slowly at 70° to 90° C., colorless transparent crystals are obtained which belong to the right rhombic system, and are combinations of an octahedron with a predominating rhombic prism. The crystals cannot be dried, but deliquesce even between folds of bibulous paper. They leave a sharply acid afterward styptic taste, and dissolve in water without decomposition. On evaporating the solution, however, the salt is decomposed and an insoluble oxyfluorid precipitated. The formula of the fluorid was found to be SbF_3, and all attempts to prepare the compounds SbF_4 and SbF_5 were unsuccessful. By mixing oxyd of antimony and carbonate of potash together in atomic proportions and adding an excess of fluohydric acid, Flückiger obtained two crystalline salts represented by the formulas $SbF_3 . KF$ and $SbF_3 . 2KF$. With the fluorids of sodium, lithium and ammonium, the fluorid of antimony forms salts represented by the formulas $SbF_3 . 3NaF$, $SbF_3 . 2LF$, $SbF_3 . 2NH_4F$. From these results it is evident that the fluorid of antimony is tribasic, bibasic, and monobasic, like phosphoric acid, so that we may represent its combinations by the general formula $SbF_3 . (1.2.3)RF$. Flückiger adopts the views of Bonsdorff, Boullay, Thomson and Hare, in regard to the constitution of the so-called fluorids, and considers them as perfectly analogous to the oxygen salts of corresponding constitution. [This view, long and earnestly maintained in this country by Dr. Hare, is gradually gaining ground at the present day, though but a few years since ridiculed or ignored by writers on systematic chemistry.]—*Pogg. Ann.*, lxxxvii, 245.

4. *Anhydrous Valerianic Acid.*—Chiozza has obtained anhydrous valerianic acid by the method which Gerhardt has applied to the isola-

tion of acetic and butyric acids. When oxychlorid of phosphorus, PCl_3O_2, is brought into contact with valerianate of potash, a violent reaction takes place and the odor of the oxychlorid disappears. By treating the mass with a weak solution of carbonate of potash, and then with ether, and evaporating the etherial solution, the anhydrous acid is obtained as a limpid, highly mobile liquid, lighter than water, and possessing a feeble odor of apples. The liquid boils at 215°, and distills over perfectly colorless: its vapor irritates the eyes and provokes coughing. The reaction by which the anhydrous valerianic acid is obtained, is represented by the equations,

$$PCl_3O_2+3(C_{10}H_9O_3, KO)=PO_5\ 3KO+3(C_{10}H_9O_2Cl)$$
$$3(C_{10}H_9O_3, KO)+3(C_{10}H_9O_2Cl)=3KCl+3(C_{10}H_9O_3)$$

the oxychlorid of valeryl, $C_{10}H_9O_2Cl$, is here first set free and then reacts on another portion of the valerianate of potash.

By the action of oxychlorid of benzoyl on valerianate of potash the author has also obtained a compound of anhydrous valerianic with anhydrous benzoic acid represented by $C_{10}H_9O_3+C_{14}H_5O_3$. It is an oily liquid, heavier than water, and leaving an odor like that of anhydrous valerianic acid. By distillation it is separated into anhydrous benzoic and anhydrous valerianic acids. Alkaline solutions transform it into valerianates and benzoates.

By the action of aniline upon anhydrous valerianic acid Chiozza has prepared valeranilide crystallizing in magnificent rectangular tables fusing at 115° C. Its formula is $NC_{12}H_6, C_{10}H_9O_2$.—*Comptes Rendus*, xxxv, 568.

5. *New compound of Cobalt.*—Saint Evre has described a remarkable compound which is obtained when a cold and concentrated solution of nitrite of potash is brought into contact with a cold and concentrated solution of nitrate of cobalt; nitric oxyd is evolved while an insoluble yellow precipitate is thrown down. The supernatant liquid contains a considerable quantity of nitrate of potash. A simple method of preparing it is to precipitate nitrate of cobalt by potash and then to pass a current of nitric oxyd through the resulting rose colored magma. The compound thus formed is of a brilliant yellow color and crystalline structure: it is insoluble in water but is decomposed by boiling water with evolution of nitric oxyd; in contact with air in this case nitric acid is formed and the liquid contains nitrate of cobalt and nitrite of potash. When suspended in water it resists for a long time the action of chlorine and is only decomposed by heating; sulphydric acid has also no effect upon it, but sulphid of ammonium produces a black sulphid of cobalt. Acids decompose the new compound with formation of red vapors; a solution of caustic potash precipitates the hydrated sesquioxyd of cobalt. Heated in the air the substance becomes at first orange yellow, then fuses, disengaging water, red vapors of hyponitric, and white vapors of nitric acid. [Saint Evre gives the formula $2(CO, KO, N_2O_8)+HO$, as representing the constitution of this remarkable compound, but his analysis was conducted by a singularly complex process which could hardly give accurate results, and the reaction with caustic potash shows conclusively that the cobalt is present as sesquioxyd and not as protoxyd.]—*Comptes Rendus*, xxxv, 552.

W. G.

6. *Separation of Manganese from Iron and Nickel;* by Dr. T. SCHIEL,* St. Louis, Mo.—If a current of chlorine is passed through a diluted solution of acetate of manganese, or better, through a mixture of chlorid of manganese and acetate of soda, the acetate of manganese is decomposed after a very short time and all the manganese precipitated as peroxyd, while the acetates of iron and of nickel are not affected under similar circumstances. Therefore, if a solution of chlorids of manganese nickel and iron contains free hydrochloric acid, a sufficient quantity of acetate of soda is added to convert all the chlorids into acetates and bind the free hydrochloric acid. The free acetic acid thus liberated, does not prevent the formation of peroxyd of manganese. By this method, cobalt cannot be separated from manganese, because it is also *partly* precipitated.

7. *Phosphoric Acid in some of its relations to Physiology and Pathology;* by D. BREED, M.D., of New York.—Early in 1850, Professor Liebig directed my attention to the chemical constitution of the nervous system, as an important and unexplorable field. My first object was to determine the constituents of the incombustible matter of the brain, by burning that organ, and then analyzing the ash. Nearly 50 per cent. of the ash of an ox's brain proved to be phosphoric acid, and as more than 40 per cent. of phosphoric acid was obtained from the ash of the brain of a hospital patient, there is little doubt that healthy human brain would yield at least 50 per cent.

Finding this extraordinary quantity of phosphoric acid in nervous matter, and believing that it must play an important though almost unknown part in the human economy, I immediately commenced a research upon the subject of phosphoric acid in urine. After making several hundred determinations† of that acid in normal human urine, I am led to the following conclusions:—

1st. A person weighing 150 lbs., in health, of regular habits, discharges unifomly about 4,000 grammes (average of 24 days) of phosphoric acid in 24 hours.

2d. The quantity is greater during the day than during the night, both per cent. and per hour.

3d. The amount of water drank in 24 hours does not materially alter the quantity of phosphoric acid discharged.

4th. Taking an excess of common salt diminishes the amount of phosphoric acid, while taking potash increases it.

From the accompanying statistics derived from experiments which I made in the hospitals of Giessen and Zürich, it will appear that diseases generally very much reduce the amount of phosphoric acid. The case of phthisis, although not having yet reached the suppurative stage, and the patient not much emaciated, gave an extremely small portion of acid, compared with the normal standard: the amount of acid was increased in the cases of epilepsy and apoplexy, and not much diminished in the case of mollities ossium.

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* By an oversight in the chemical dictionary of Booth and Morfit, article "Madder," Schiel's name is written "Shiel;" in the article "Sanguinarin," it is even written "Scheele."

† See "Annalen der Chemie und Pharmacie," 1851; also the Report of the American Association for the Advancement of Science, 1851.

As it has lately been shown that nine or more species of phosphoric acid exist, it becomes interesting to inquire, what modification that substance assumes in urine; and, as tending to the solution of the problem, the following results are important.

By neutralizing a known quantity of phosphate of potassa in solution, with a solution of perchlorid of iron (according to the well-known method of Guy-Lussac for alkalimetry), in presence of acetate of soda, and then determining the amount of iron required to neutralize the phosphoric acid, I found that one atom of peroxyd of iron (Fe_2O_3), corresponds to one atom of phosphoric acid (PO_5). We doubtless have the same atomic proportions (Fe_2O_3, PO_5), in the phosphate of iron produced by treating urine with perchlorid of iron; therefore, as water is present in both these cases, we probably have in urine tribasic phosphoric acid, corresponding to the following formula: $Fe_2O_3 + 2HO, PO_5$.

	Cubic centimetres.		Grammes.
Case 1st, Rheumatism in the joints.—Urine of 24 hours,	1322	Phos. acid,	2·260
" "	1050	" "	2·793
" "	1290	" "	3·127
2d, Carcinoma of the liver: " "	580	" "	2·204
" "	750	" "	2·191
" "	700	" "	1·862
" "	765	" "	2·107
" "	1187	" "	2·812
3d, Phthisis: " "	1296	" "	1·630
" "	1142	" "	1·411
" "	1219	" "	1·790
4th, Intermittent Fever: " "	920	" "	1·120
" "	763	" "	2·421
" "	947	" "	2·782
" "	1303	" "	2·970
5th, Apoplexy: " "	1188	" "	5·428
" "	1385	" "	5·540
" "	1415	* " "	5·660
" "	1415		5·660
6th, Epilepsy: " "	2294	" "	8·260
" "	1275	" "	5·679
" "	1820	* " "	5·005
" "	1820		5·005
" "	1217	* " "	3·407
" "	1217		3·407
" "	1165	* " "	3·391
" "	1165		3·391
7th, Mollities Ossium: " "	587	* " "	4·465
" "	587		4·465
" "	544	* " "	3·268
" "	544		3·268
" "	633	* " "	3·070
" "	633		3·070

* One half of the amount for 48 hours.

III. Mineralogy and Geology.

1. *On Petalite and Spodumene;* by C. Rammelsberg, (Ann. der Physik und Chemie, lxxxv, 544, 1852.)—The discrepancies in the analyses of these minerals have led M. Rammelsberg to new researches with regard to their composition, and we here give an abstract of his paper on the subject.

The analyses were made by means of carbonate of soda and hydrofluoric acid, and with special precautions for accuracy. The following are the results. Specific gravity of the Utö mineral, 3·1327; of that of Tyrol, 3·137.

	Utö.			Tyrol.		
	With carb. soda.	With hydrofl. acid.		With carb. soda.	With hydrofl. acid.	
Silica,	65·02			*undet.*	65·53	
Alumina,	27·70	29·47	30·26	27·91	29·97	29·25
Protox. iron,	*trace*	*trace*	*trace*	*undet.*	1·40	1·45
Lime,	0·80	0·20	*undet.*	0·84	0·87	1·07
Magnesia,	0·15	*trace*		0·09	0·06	0·06
Lithia,		5·50	5·35			4·49
Soda,		0·56	0·51			0·07
Potash,			0·14			0·07

Mean of the results

	$\dot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{L}i$	$\dot{N}a$	$\dot{K}$	
1. Utö.	65·02	29·14	*trace*	0·50	0·15	5·47	0·46	0·14	=100·88
Oxygen,	33·78	13·61		0·14	0·06	3·00	0·11	0·02	
2. Tyrol.	65·53	29·04	1·42	0·97	0·07	4·49	0·07	0·07	=101·61
Oxygen,	34·05	13·56	0·31	0·26	0·03	2·46	0·02	0·01	

The first gives the oxygen ratio, 3·33 : 13·61 : 33·78=1 : 4·0 : 10·1.
The second " " " 3·09 : 13·56 : 34·05=1 : 4·4 : 11·0.
Taking 1 : 4 : 10 as the most probable ratio, the formula becomes

$$\dot{R}^3\ddot{S}i^3+4\dot{A}l\ddot{S}i^2,$$

making spodumene a compound of two *bisilicates.**

The analysis of Hagen of the Utö mineral, gave as a mean, 65·022 of silica to 26·837 of alumina, with 3·836 of lithia, affording the oxygen ratio 3·00 : 12·53 : 33·79=1 : 4·18 : 11·26, which Hagen makes $1 : 4\frac{1}{2} : 12$. Berzelius found the ratio 1 : 4 : 12. For the Sterling (Mass.) spodumene Hagen obtained silica 65·247, and alumina 27·556.

M. Rammelsberg next cites the analyses of Mr. G. J. Brush from this Journal (vol. x, p. 370), and alludes to its agreeing with Stromeyer's analysis of the Utö mineral in the silica, in which this last mentioned chemist differs from Arfvedson, Regnault and Hagen who found 65 to 66 per cent. Specific gravity of the Norwich spodumene according to Mr. Brush, 3·18.

In an earlier analysis of the spodumene of Conway, Bowen found 65·3 p. c. of silica and 24·5 of alumina.

From all the analyses, Rammelsberg infers that the formula he has deduced is the true formula.

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* Kobell early deduced a similar formula, before soda was known to exist in the mineral.

The measurements of the crystals given by Hartwall and Dana, with the figure by the latter,* are next cited, and a comparison made with the form of crystals of augite, the near identity with which was first mentioned by the latter. These measurements were approximations only, made by means of the common goniometer, and some of the faces were quite uneven. The following comparison is made.

Augite.		Spodumene.	
$M : M =$	87° 06′	N : N =	87°
$M : r$	133 33	N : M	113 to 133° 30′
$M : l$	136 27	N : l	137 to 136 30
$r : l$	90 00	M : l	90
$r : t$	74 01	P : M	69 40
$s : s$	120 38	a : a	117
$o : r$	103 20	a : M	100 30
$z : z$	80 28	$t^2 : t^2$	79 30
$z : l$	139 56	$t^2 : l$	139 45 to 140°
$o : o$	95 36	$a^2 : a^2$	
$o : r$	118 24	$a^2 : M$	116

The plane b^3 has not been observed in augite. Its inclination to M was ascertained to be 107°. It must therefore be the plane $a : \frac{1}{3}b : \infty c$, which in augite would have for its inclination on M, 106° 57′. The other planes will have for the axes a, b, c, (a and b being the lateral and c the vertical):—N (M Augite) $= a : b : \infty c$; $M(r) = a : \infty b : \infty c$; $b\,(l)$ $\infty a : b : \infty c$; P $(t) = \infty a : \infty b : c$; $a\,(s) = a' : b : c$; $t^2\,(z) = \infty a : b : 2c$; $a^2\,(o) = a' : b : 2c$; $b^3 = a : \frac{1}{3}b : \infty c$.

The isomorphism of spodumene and augite is an example of a similarity of form with unlike constitution. Still there is some analogy between them. Calculating the atomic volume, we have for spodumene (supposing the soda to the lithia as 1 to 27, and the specific gravity 3·13) 2840. Dana has found that the atomic volume of isomorphous bodies are very nearly equal when the atomic volume is divided by the number of atoms of elements in the compound. The atomic weight of diopside (lime-magnesia augite) is 2043·74, the specific gravity 3·28; hence the atomic volume =623. The number of atoms of elements in $\dot{C}a^3\,\ddot{S}i^2 + \dot{M}g^3\,\ddot{S}i^2$ is 28, and therefore $623 \div 28 = 22$.† In spodumene the number of atoms is 66; or if alumina contains 1 of aluminium instead of 2, it is 62; dividing 2840, by these numbers we have 43 or $45\frac{1}{2}$.

Petalite.—The analysis of petalite afforded Rammelsberg as the mean of his results,

	$\ddot{S}i$	$\ddot{A}l$	$\dot{L}i$	$\dot{N}a$
	77·79	18·58	3·30	1·19
Oxygen,	40·42	8·67	1·81	0·30

Affording the ratio $2{\cdot}11 : 8{\cdot}67 : 40{\cdot}42 = 0{\cdot}95 : 3{\cdot}86 : 18 = 1 : 4{\cdot}1 : 19{\cdot}1$. $1 : 4 : 18$ gives $3\dot{R}\,\ddot{S}i^2 + 4\ddot{A}l\,\ddot{S}i^3$; and $1 : 4 : 20$ gives $\dot{R}^3\,\ddot{S}i^4 + 4\ddot{A}l\,\ddot{S}i^4$. The former affords the percentage, Silica 76·43, alumina 18·90, lithia 3·44, soda 1·23=100; the latter, Silica 78·27, alumina 17·42, lithia 3·17,

* This Jour. [2], x, 119, 264, and Dana's Mineralogy, 3d edit. p. 693.

† Taking the general formula $\dot{R}^3\,\ddot{S}i^2$ for the augite (in the same way as the general formula is used for the spodumene) and it gives for the number of atoms 14, and the atomic volume 44. In the next sentence above we have made a slight correction.—J. D. D.

soda 1·14=100. *Castor*, according to Plattner, afforded silica 78·01, alumina 18·85, lithia 2·76, agreeing nearly with petalite in its alumina and silica. Still according to Plattner it contains no soda, and it afforded the ratio 1 : 6 : 27. We have not therefore as yet sufficient grounds for pronouncing them identical.

2. *On Humite*; by M. RAMMELSBERG, (Ibid. vol. lxxxvi, p. 413.)—Rammelsberg gives the following as the results of his analyses of the three varieties or types of Humite, (see this Journal, vol. xiv, p. 175.)

	$\dot{S}i$	$\dot{M}g$	$\dot{C}a$	$\dot{F}e$	$\dot{A}l$	Fe
I.	34·80	60·08	——	2·40	——	3·47 = 100·75
II.	33·26	57·92	0·74	2·30	1·06	5·04 = 100·32
III.	36·67	56·83	——	1·67	——	2·61 = 97·78

These give the general formula $(4\dot{M}g\,Fl + Si\,Fl^2) + n\,\dot{M}g^4\dot{S}i$, in *which n* equals, for Chondrodite, 12; for Humite of the type II, 18; for I, 27; for III, 36. Rammelsberg shows farther the equality of atomic volume between Olivine and Humite, according with the similarity of crystallization pointed out by Scacchi.

3. *Fossil Bones, probably Reptilian, from the Coal formation of Nova Scotia, discovered by Mr. Dawson and Sir Charles Lyell*, (Boston Evening Traveller, Nov. 10, 1852.)—In our report of the Lowell Lecture of last night, allusion is made to the first example of the bones of a fossil reptile of the carboniferous epoch, discovered on the American continent. They were found by Mr. Dawson, of Pictou, and Sir Charles Lyell, in September last, in the interior of an erect fossil tree, on the shore of the Bay of Fundy at the South Joggins near Amherst.

The largest of the fossil species appears to have been between two and three feet long. Another, of which the vertebral column is preserved, was much smaller, probably not more than 6 inches in length.

In the same group of fossils are observed fragments of jaw-bones with conical teeth, and sculptured dermal plates, probably parts of the same batrachian quadrupeds. There was also found associated with them the shell of a Mollusk, apparently a pulmoniferous gasteropod, (Cyclostoma or Pupa?) a family of land shells, of which no representatives had previously been met with in rocks of so high antiquity.

IV. BOTANY AND ZOOLOGY.

1. *Mohl, Grundzüge der Anatomie und Physiologie der vegetabilischen Zelle.* Braunschweig, 1851; pp. 152, 8vo.—This is a separate issue of an article by Prof. Mohl in Wagner's *Handwörterbuch der Physiologie*. It is a condensed systematic treatise on Vegetable Anatomy and Physiology; and, as it is the only work in which Prof. Mohl has treated the subject in a general manner, it is one of great importance; the author being the very highest authority in vegetable anatomy and phytogeny. We are happy to announce that an English translation has been prepared by Mr. Henfrey, which will shortly be published by Van Voorst. When it appears we hope to present our readers with an abstract of the work. A. G.

2. *Hermann Schacht, Die Pflanzenzelle, der innere Bau, und das Leben der Gewächse.* Berlin, 1852; pp. 472, tab. 20, roy. 8vo.—This is the latest and fullest general treatise on the whole subject of vegetable anatomy and physiology; and by an author who has exhibited

much talent for this kind of research. It is illustrated by 390 good original figures, on stone, in 20 plates. As to the formation of the embryo he holds the Schleidenian view.—In connexion with the above, we may enumerate two treatises by Hofmeister of Leipsic, namely, *Die Entstehung des Embryo der Phanerogamen*, 1849, pp. 89, tab. 14, 4to, and *Vergleichende Untersuchungen der Keimung, Entfaltung und Fruchtbildung höherer Kryptogamen, und der Samenbildung der Coniferen*, 1851, pp. 179, tab. 33;—two works of which we should be glad to give an extended analysis. A. G.

3. *Lindley, Folia Orchidacea; an Enumeration of the known species of Orchids.* Part I. Oct., 1852. 8vo. London. Published for the Author, by J. Matthews.—A revision and complete enumeration of the Orchideæ now known has long been greatly wanted; and no one is competent and prepared for the undertaking except Dr. Lindley. His *Genera and Species of Orchidaceous Plants* was commenced in 1830, and terminated in 1840; since which time the number of known species has multiplied enormously. It is stated that there are now in cultivation in Great Britain a greater number of species than were known in 1830 from books and herbaria taken together. The plan of the present revision of the family is different from that of the former work. The genera do not follow in regular sequence, according to any established plan of arrangement. But those of which the author possesses the most complete information are taken first; while those of which he has imperfect materials are postponed, in hope that the requisite data may be supplied while the publication is in progress. To elicit the information needed, a list of genera imperfectly or wholly unknown to Dr. Lindley is given on the cover;—in which we are surprised to find one of our North American Genera, namely, the *Tipularia* of Nuttall. We call the attention of our correspondents and botanical friends, who possess duplicates or can obtain specimens of this rare plant, in order that the want may be supplied. Specimens sent to the writer of this notice will be duly forwarded to Dr. Lindley. The first part of the Folia Orchidacea contains *Stanhopea*, *Odontoglossum*, and five smaller genera. Each genus is paged separately so that the whole may be arranged systematically or alphabetically, when the work is completed; and the date of publication is printed at the bottom of the first page of each genus.

The second part, containing *Epimedium*, was probably issued at Christmas. A. G.

4. *Remarks on the Mode of Vegetation of European and North American Trees transported to Madeira;* by Prof. Oswald Heer, (Ann. Mag. Nat. Hist., [2], x, 396, from Bib. Univ. de Geneva, Aug., 1852, p. 325.)—M. Heer, of Zurich, so well known by his observations on the botanical geography of the Swiss mountains, having been compelled by the state of his health to make some stay at Madeira, has employed his time while there, in studying, in various points of view, the vegetation of that island, the climate of which is remarkably equable throughout the year.

Since his return he has laid before the Société Helvétique des Sciences Naturelles, several interesting observations relative to the periodical phenomena of vegetation. After remarking that all the woody plants of Madeira are evergreen trees or shrubs, blossoming very often

during the cool season, he observes how much the species introduced from more northern countries contrast with these indigenous species in their mode of vegetation.

The oak and the beech, for instance, continue to lose their leaves during the winter, although the weather is then milder than it is in several parts of Europe during the summer. Thus, at Funchal, the leaves of oaks (*Quercus pedunculata*) planted in some public gardens and promenades, began to grow yellow at the end of October, and gradually became dried up to the 1st of January. Some isolated trees began to shoot by the 10th of January, and were green again on the 6th of February; but all the others remained in a state of repose and were not generally covered with new leaves until the 20th of February. In Mr. Gordon's garden, at an elevation of 1800 feet, they were a month later.

The leaves of the beech became yellow at Funchal by the 8th of November, at Mr. Gordon's garden by the 28th of October. The leaves, or at least the greater part of them, remained in a dry state upon the trees, until they began to shoot in the spring, which was about the 1st of April. At Funchal, the terminal buds were open by the 8th of April, and the lateral a little later.

At Glaris, the period of repose of the beech on an average is 194 days; in Madeira, where the cold season is like the summer at Glaris, it is 149 days. The difference is only 45 days. The oak in Switzerland has a period of repose nearly equal to that of the beech, whilst at Madeira it is only 110 days, or 49 days less than the beech. M. Heer supposes that this difference may arise from the beeches of Madeira having been introduced from England and the oaks from Portugal, so that the latter would have previously acquired the habit of losing their leaves later and vegetating sooner than in the center of Europe.

M. Heer ought perhaps to have added, what he no doubt knows, that sudden variations of temperature in the twenty-four hours, especially the instantaneous diminution to 32° Fahr. or lower, are one of the great causes of the fall of the leaves in Switzerland. The absence of these variations retards the phenomenon in the west of Europe, and still more in Madeira.

In the facts stated by M. Heer,—facts of which we previously had examples in the hothouse culture of tropical plants,—there is a proof of that important physiological law, too often forgotten by meteorologists, that *the same temperature or the same sum of temperatures, combined with the season, does not always produce the same effect upon organized beings.*

Every species is as it were a machine which performs its functions under the influences of external causes, modified by particular internal conditions. These vary not only between one species and another, between one race of a species and another, and even up to a certain point between one individual and another, but also between one period and another,—the same heat after the repose of vegetation for instance, not producing the same effect as in other circumstances.

In Madeira, the *Platanus occidentalis*, a native of the United States, loses its leaves very slowly from the middle of October, or rather they gradually become yellow and fall afterwards from the action of wind

and rain. The repose is complete in January, February, and up to April, during a period of 87 days. The *Liriodendron tulipifera*, also a native of North America, has a complete repose of 151 days.

The apple and pear trees generally begin to lose their leaves in December. They come into flower, at Funchal, by the 7th of April, and their fruit is collected in August. There are, however, varieties of apple and pear trees which flower and produce fruit twice in the year, and one variety of apple is perpetually in flower and fruit. The peach trees about the 4th of November already exhibit some flowers amongst their leaves; they then, to the great astonishment of M. Heer, continued blossoming in abundance during the months of December and January, and the fruit came to maturity from the 23d of February to the end of the summer. In February there were flowers on the upper parts of the trees and fruit below, and it was also then the leaves were renewed, the interval between the falling and shooting of the leaves being scarcely sensible. The vines around Funchal began to lose their leaves about the 24th of October. The soil of the vineyards in winter offered the singular appearance of being covered with the flowers of *Oxalis speciosa* (a Cape plant) and of *Calendula arvensis*. New leaves appeared by the end of March, and by the 8th of April the vines were completely in leaf, with young floral grapes. The flowers open at the end of April and the beginning of May, and the vintage takes place in September. The repose lasts 157 days.

5. *On Fossil Pachydermata in Canada;* by T. Cottle, (from a letter to the Editors of the Annals of Natural History, [2], x, 395, dated Woodstock, Upper Canada, April, 1852.)—I think it may be worth while to record the first discovery of the remains of one of the large extinct Pachydermata in Canada; for the Mastodon's remains mentioned by Lyell are found on the right bank of the Niagara, which is not in the province, although so close as to be only divided from it by that river.

At the latter end of January, in cutting through, for the transit of a railway, a narrow spit of land at the head of Lake Ontario known as Burlington Heights, two bones of an Elephant were discovered (*E. primigenius?*), viz. the whole of the right ramus of the lower jaw to beyond the symphysis, and a tusk. The tusk was much curved, as will appear from the following dimensions:—length along the greatest curve, 6 ft. 8 in.; from the base straight to the point, 4 ft. 2½ in.; two feet from the base, to which length I suppose was imbedded in bone, straight to the point, 3 ft. 3¾ in. The dimensions of the jaw are—from the angle to the symphysis 19 in., from the condyloid process to the symphysis 2 ft. 2 in., from the angle to the top of the condyloid process 18 in., from base of angle to top of the coracoid process 12 in. The jaw contained only one molar; this tooth was very perfect; the width of the upper surface 3¼ in., the length 13, of which 4¾ had been used.

The remains were found 40 feet below the surface and 60 above the level of the lake, in a layer of sand, superimposed on which were successive layers of cemented gravel and sand, the layers of gravel varying both in width and in the size of the pebbles: this narrow spit of land seems to have been a bar formed at the mouth of a large estuary

which must have flowed into Lake Ontario. To the east of this bar is Burlington Bay, the head of Lake Ontario, from which it is separated by a similar bar through which a canal is cut into the lake, and which bank I am informed is still rising. To the west are the Dundas marshes, which find their exit into Burlington Bay round the point of Burlington Heights, and through which the Desjardin Canal is carried. Behind Dundas, running east and west, is a long, deep and wide valley bounded on the north and south by ridges of Niagara limestone, and down which valley doubtless once flowed a large body of water.

In sinking a coffer-dam near this spot for the foundation of a bridge where the railroad will cross the Desjardin Canal, were found, deep in the silt, the scapular and some fragments of the bones of the extremities of an herbivorous animal about the size of a fallow-deer.

V. Astronomy.

1. *The Nineteenth Asteroid.*—The planet discovered on the 22d of August, 1852, by Mr. J. R. Hind of London, has been named *Fortuna.*

2. *The Twentieth Asteroid*, (Comptes Rendus, xxxv, 674.)—Prof. A. de Gasparis has adopted for the planet discovered by him on the 19th of September, 1852, the name *Massalia*, out of respect to M. Chacornac of Marseilles, who discovered the planet independently on the 20th. The following elements of this planet, computed by Mr. George Rümker from the Hamburg observations of September 30, October 26, and November 19, have been communicated to the *Astronomical Journal.*

Epoch 1852, November 0, m. t. Berlin.

Mean longitude,	297° 0′ 46″·0	
Longitude of perihelion,	94 32 39 ·7	Mean Equinox
" " asc. node,	207 8 47 ·6	1853, Jan. 0.
Inclination,	0 40 28 ·1	
Angle of excentricity,	10 3 27 ·5	
Log. of semi-axis major,	0·3890493	
" mean daily motion,	2·9664326	

3. *New Planets—Twenty-first Asteroid*, (Astr. Jour., No. 52.)—At Paris on the 15th of November, 1852, another planet, which has been named *Lutetia*, was discovered by Mr. H. Goldschmidt. It resembled a star of the 9·10 magnitude. Mr. G. Rümker has computed the following elements, from observations made at Paris, November 18, and Hamburg, November 28 and December 3.

Epoch 1852, December 0·0, Berlin m. t.

Mean longitude,	61° 29′ 23″·3	
Long. of perihelion,	309 53 19 ·4	Mean Equinox 1853·0.
" " asc. node,	78 38 48 ·4	
Inclination,	3 19 49 ·7	
Angle of excentricity,	19 51 55 ·2	
Log. of semi-axis major,	0·4157699	
" mean daily motion,	2·9263517	

4. *Twenty-second Asteroid*, (Astr. Jour., No. 52.)—On the 16th of November, 1852, Mr. J. R. Hind discovered a new planet which he

estimates as of the 10·9th magnitude. By comparison with LALANDE 10056, he obtained Nov. 17, $11^h\ 51^m\ 52^s$ Gr. m. t., R. A. $5^h\ 12^m\ 49^s{\cdot}38$, and N. P. D. $65°\ 26'\ 44''{\cdot}5$. Mr. E. Vogel has calculated the following elements from observations of November 19, 24 and 30.

Epoch 1852, December 0·0, Greenwich m. t.

Mean longitude,	. . .	$22°\ 27'\ 0''{\cdot}5$
Long. of perihelion,	. .	$46\ 13\ 28\ {\cdot}9$ } Mean
" " asc. node,	. .	$66\ 53\ 6\ {\cdot}1$ } Eqx. 1852·0.
Inclination,	. . . .	$14\ 20\ 12\ {\cdot}6$
Angle of excentricity,	. .	$6\ 0\ 11\ {\cdot}8$
Log. of semi-axis major,	. .	0·4685289
Mean daily motion,	. . .	$703''{\cdot}41748$

Mr. Adams, being requested to name this planet, has proposed to call it *Calliope.*

5. *Twenty-third Asteroid*, (Astr. Jour.)—In a letter to the editor of the *Astronomical Journal*, Mr. J. R. Hind announces the discovery of another planet at $6^h\ 30^m$ of Dec. 15, 1852. He describes it as shining like a star of the 10·11th magnitude, with a pale bluish light. By comparison with LALANDE 6129, he found the following positions:

1852.	Greenwich m. t.	R. A.	N. P. D.
Dec. 15.	$7^h\ 18^m\ 39^s{\cdot}2$	$3^h\ 12^m\ 4^s{\cdot}98$	$73°\ 10'\ 16''{\cdot}4$
	$8\ 42\ 2\ {\cdot}0$	$3\ 12\ 2\ {\cdot}70$	$73\ 10'\ 3''{\cdot}9$
Daily motion about . .		-39^s	$-3''{\cdot}5$

Mr. Bishop, at the request of Mr. Hind, has selected for this planet the name *Thalia.*

VI. Miscellaneous Intelligence.

1. ***Ericsson's Caloric Engine.***—The moving power in Ericsson's Engine is well known to be the expansion of air by heat, which expansion at 32° F. is about $\frac{1}{490}$ for each degree of Fahrenheit added. It is now a fact that this power has been proved sufficient to move a vessel of the largest size at the rate of 7 miles an hour; and the public wait with much interest for the final trials that shall test its claim to be admitted as a successful rival of steam. For a large and accurate drawing of Ericsson's Caloric Engine, we refer our readers to a plate in the February number of Appleton's Mechanics' Magazine, which was furnished by Capt. Ericsson himself. The following particulars are mainly from this plate, and from Capt. Ericsson's description accompanying it. It represents the stationary test-engine, which is better for illustration than that in the ship.

In this stationary engine, two working cylinders 5 feet in height, with pistons 6 feet in diameter, stand about 1 foot apart. Each of these cylinders is concave at bottom, and rests directly over the fire. Upon the top of each working cylinder is built a second smaller cylinder (called the *supply cylinder*) wholly separate in its chamber from that below; it is nearly 5 feet in diameter, and $4\frac{1}{2}$ in height. This upper cylinder appended to each working cylinder for supplying the air, has also its piston; and both pistons, having their centers in the same line, work up and down together with the same shaft; the two pistons being connected by two rods. The working piston, or that of the lower cyl-

inder, is two feet or so thick, the interior being filled with clay and charcoal to prevent the conduction of heat through from below.

On one side of either large cylinder near the bottom, there is an opening for the entrance of the air for raising the piston and for its passage out as the piston descends; and close by this opening, just outside, there is a mesh-work of wire, called the *regenerator*, through which the air passes, both on entering and going out. This regenerator is 26 inches high and wide, and is filled with 200 disks of wire-net, having 10 meshes to the inch, making 67,600 meshes in each disk, and 13,520,000 in the whole regenerator, forming thus an apparatus for cooling the air that leaves the engine, and at the same time for warming the air that enters. There are 41½ miles of wire in each regenerator, and the amount of surface it presents is 2014 square feet, equal to the entire surface of 4 steam boilers, 40 feet long, and 4 feet in diameter. The air going out loses about 480° F. of its temperature, and the same amount is the next moment communicated to the air passing in.

The supply-cylinder, (upon each working cylinder,) is simply a pump for pumping in air. As its piston descends (simultaneously with the working piston), a valve at top opens from external pressure, and air passes in from without. On rising, the pressure closes this valve, and opens another; and through the latter the air passes into a flue, opening into the *air-receiver*—a large rectangular box placed vertically, measuring 7 feet by 3½. From the bottom of this air-receiver, a flue leads to the regenerator, and so into the large cylinder below the working piston. Thus there is a free communication for the air from the upper cylinder (the supply-cylinder) through the air-receiver alongside into the bottom of the lower or working cylinder, the air passing through the *regenerator* just before entering the latter. The ascent of the upper piston expels the air from the upper cylinder, and compels this air to make this circuit. Just before reaching the regenerator, there is a valve, which closes through the action of the engine, when the air has raised the piston ¾ths of the full up-stroke; but until this moment on the rise of the pistons, the communication is free between the upper part of the upper cylinder and lower part of the lower cylinder. When the working piston has reached its full height, the air which has raised it is to be got rid of: for this purpose, another valve opens, and this air (first making its way, as above said, through the regenerator, where it is deprived of its heat), passes out through this valve, and escapes into the atmosphere; when the piston begins to fall by its weight.

The commencing *descent* of the piston again opens the valve at the top of the supply cylinder, letting in the air from the atmosphere around; and next, its *rise* closes this valve and opens that one leading through the air-receiver and regenerator to the lower cylinder below the piston; and so it goes on as just described.

We have thus given the particulars respecting one of the great cylinders, and its subsidiary supply-cylinder. The other of the pair is precisely similar. The two shafts, as usual, connect with a common working beam; and of course the rise of the piston on one side concurs with atmospheric pressure in producing a descent in that of the other.

The fire acts directly against the bottom of the large cylinders. When the engine is in full action, the air entering, say at a temperature of 60°, will be heated to 450° on passing through the regenerator, by taking up the heat left in the regenerator by the hot air that had just before passed out; and as 480° are all that are required, the balance is supplied by the fire. The air at 480°, on now leaving the cylinder, is cooled down to 90° F., or but 30° above the temperature before entering. So great is the effect of the regenerator that the temperature near the regenerator on the side next the cylinder, and that on the opposite side, in all cases differ by at least 350° F., when there are sufficient fires in the furnaces.

Mr. Ericsson makes the following statements:

"In regard to *loss of heat*, the result of ample trial has been, that at no time has the temperature of the escaping air exceeded that of the entering air by more than 30°. As this differential temperature exhibits the *positive loss of heat*, it becomes important to ascertain its amount in pounds of coal: the area of the supply piston is 2626 square inches, and its stroke two feet; hence $36\frac{4}{10}$ cubic feet of atmospheric air is supplied for each stroke, and therefore at 30 strokes 1092 cubic feet, and for both cylinders 2184 cubic feet per minute=131,040 cubic feet per hour. The weight of atmospheric air is nearly $13\frac{1}{2}$ cubic feet to the pound, and hence it will be seen that 9706 pounds of air pass through the engine every hour. We know that one pound of coal will raise the temperature of 10 pounds of water 1100°; the specific heat of water being to that of air as 26 : 100, it will also be seen that $38\frac{4}{10}$ pounds of air will be elevated in temperature 1100° with one pound of coal; now the observed loss of heat in the engine being 30°, the fact will be established that the loss will be only one pound of coal for every 1408 pounds of air passed through the engine, which, on 9706 pounds, proves the actual loss of heat in both regenerators to be only $6\frac{8}{10}$ pounds of coal per hour; a pressure of 13 pounds being sustained in the receiver exerting 60 horse-power, with an actual waste of only 6·8 pounds per hour, it will be found that *two* ounces of coal per hour per horse-power is the quantity of fuel absolutely wasted in the process of transfer. The actual consumption of the engine is however, nearly 40 pounds per hour, which is thus proved by the foregoing to be chiefly carried off by radiation of heat; on a large scale much of that radiation will be prevented; as the machine stands, a horse-power is produced by a consumption of less than 11 ounces to the horse-power per hour.

"The following particulars are of considerable practical importance:

"1st. The valves *g* and *h* [for the ingress of air to the lower cylinder and egress from it] are *not* subjected to heat, the caloric being taken up by the wires before reaching the valves.

"2d. The temperature of the packing of the working pistons does not exceed boiling heat at any time.

"3d. As only a slow radiating fire is needed, it has been found that common whitewash, applied to the under side of the heater, remains for several weeks; this proves conclusively that the effect of the heat is quite harmless.

"4th. A hole of half an inch in diameter, kept open for several hours in the valve chest, does not sensibly affect the pressure in the air-receiver, so abundant is the supply of air; this fact has surprised all practical men who have seen the engine; it proves completely that the machine need not be perfectly air-tight, as supposed by many.

"5th. After putting a moderate quantity of fuel into the furnace, it has been found that the engine works with full power for three hours without fresh feed, and after removing the fires entirely, it has frequently worked for one hour."

We pass from these observations on the stationary test-engine to a few words on the ship, of which, Mr. Ericsson in his paper does not particularly speak.

In the ship Ericsson, there are 4 working cylinders, the diameter of each being 168 inches, and the stroke 6 feet. The diameter of the supply cylinders is 137 inches. Iron wire of one-sixteenth of an inch is used for the regenerator. The amount of coal consumed by the four furnaces per day, is 6 to 7 tons. The disks of the regenerators have each 500,000 meshes, and the temperature of the air within the working piston when in action is stated at 444° F. The valve cutting off the air on the up stroke is closed when the piston has risen $\frac{63}{100}$ths of the whole stroke.

We do not at present undertake to discuss the probable success or failure of this important enterprise. We have been told that the ship draws with its present engines and without cargo or coal, 17 feet of water. It remains to be seen whether the increase of rapidity from 7 miles an hour to *fourteen* does not prove impracticable, as many fear and others hope; the contrary must be the desire of all well-wishers of humanity.

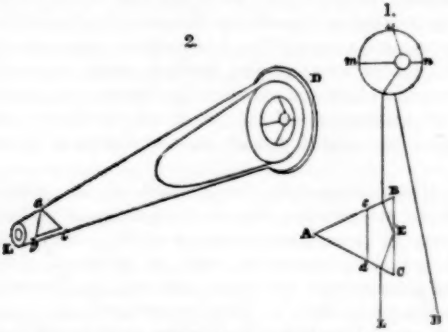
2. *Toronto Observatory.*—In the address of the president of the Canadian Institute at Toronto, Capt. J. H. Lefroy, we observe the announcement that the home government is about to withdraw from Canada "the military detachment by which a series of observations in magnetism and meteorology has been sustained in the neigborhood of Toronto since the year 1840." This removal will be a great misfortune to science, as it detaches Capt. Lefroy from his field of successful labor, in which the continent has had a deep interest; and especially so, if—as has been intimated to us—the fine collection of instruments by means of which these observations have been made during so considerable a number of years, should also be withdrawn from this continent and returned to England.

If its fate as a national observatory is sealed,—and it appears to be actually so,—we shall be gratified to learn that the local government of Canada, encouraged by the efforts and influence of its enlightened citizens, should favor the establishment of a Colonial Physical Observatory on the same basis, and if possible retain the valuable instruments now at Toronto. Were the undertaking to be sustained by the talent and science which we know to exist among the people of the province, as well as among military gentlemen occasionally resident in Canada, we cannot doubt that it would be successful in contributing largely, as heretofore, to the progress of physical science on this continent. For magnetic, meteorological and auroral observations, Toronto is one of

the most important points in North America. We hope to hear that active efforts have been made for the establishment of such an Institution and we shall cordially wish it success.

The self-registering magnetical instruments that have been successfully used in Canada by Capt. Lefroy, are peculiarly excellent and exact in their records, and it is very desirable that similar instruments should be introduced at Washington, Cambridge, and other observatories in the United States.

3. *The Total-Reflexion Stereoscope;** by Sir David Brewster, (Phil. Mag., [4] iii, 20.)—This form of the stereoscope requires only a small prism and *one* diagram, or picture of the solid, as seen by one eye; the other diagram, or picture which is to be combined with it, being created by total reflexion from the base of the prism. This instrument is shown in fig. 1, where D is the picture of a cone as seen by the left eye L, and ABC is the prism, whose base BC is so large that when the eye is placed close to it, it may see, by reflexion, the whole of the diagram D. The angles ABC, ACB must be equal, but may be of any magnitude. Great accuracy in the equality of the angles is not necessary; and a prism constructed by a lapidary out of a fragment of thick plate-glass, the face BC being one of the surfaces of the plate,



will answer the purpose.† When the prism is placed at *abc*, fig. 2, at one end of a conical tube LD, and the diagram D, at the other end, in a cap which can be turned round so as to have the line *mn*, which passes through the centre of the base and summit of the cone parallel to the line joining the two eyes, the instrument is ready for use. The observer places his left eye at L, and views with it the picture at D, as seen by total reflexion from the base BC or *bc* of the prism, figs. 1 and 2, while with his right eye he views the same picture directly. The first of these pictures being the reverse of the second D, like all pictures formed by one reflexion, we thus combine two dissimilar pictures into a *raised* cone, as in the figure, or into a *hollow* one, if the picture at D is turned round 180°.

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* The brief notice of this stereoscope on page 141 is incorrect.

† In this case the prism may have the form Bc*d*C, fig. 1, the parallel sides BC, *cd* being the original faces of the piece of the plate-glass, and the inclined faces Bc, C*d* only, the work of the lapidary.

If the conical tube LD is held in the left hand, the left eye must be used; and if in the right hand, the right eye must be used; so that the hand may not obstruct the direct vision of the drawing by the eye which does not look through the prism. The cone LD must be turned round slightly in the hand till the line *mn* joining the centre and apex of the figure is parallel to the line joining the two eyes. The same line must be parallel to the plane of reflexion from the prism; but this parallelism is secured by fixing the prism and the drawing.

It is scarcely necessary to state, that this stereoscope is applicable only to those diagrams and forms where the one image is the reflected picture of the other.

If we wish to make a microscopic stereoscope of this form, or to magnify the drawings, we have only to cement plano-convex lenses, of the requisite focal length, upon the faces AB, AC of the prism, or what is simpler still, to use a section of a deeply convex lens, and apply the other half of the lens to the right eye, the face BC having been previously ground flat and polished for the prismatic lens. By using a lens of larger focus for the right eye, we may correct, if required, the imperfection arising from the difference of paths in the reflected and direct pencils. This difference is so trivial, that it might be corrected by applying to the right eye the central portion of the same lens whose margin is used for the prism.

4. *Notice of a Chromatic Stereoscope;* by Sir David Brewster, K.H., F.R.S., V.P.R.S. Edin., (Phil. Mag., [4] iii, 31.)—In the year 1848, I communicated to the British Association, at Swansea, a brief notice of the principle of this instrument.*

If we look with both eyes through a lens, about $2\frac{1}{2}$ inches in diameter or upwards, at an object having colors of different refrangibilities, such as the colored lines on a map, a red rose among green leaves, or any scarlet object upon a blue ground, or in general any two simple colors not of the same degree of refrangibility, the *two* colors will appear at different distances from the eye of the observer.

In this experiment we are looking through the margin of two semi-lenses or virtual prisms, by which the more refrangible rays are more refracted than the less refrangible rays. The doubly-colored object is thus divided into two as it were, and the distance between the two blue portions is as much greater than the distance between the two red portions (red and blue being supposed to be the colors) as *twice* the deviation produced by the virtual prism, if we use a large lens or two semi-lenses, or by the real prisms, if we use prisms.

The images of different colors being thus separated, the eyes unite them as in the stereoscope, and the *red* image takes its place nearer the observer than the *blue* one, in the very same manner as the two nearest portions of the dissimilar stereoscopic figures stand up in relief at a distance from their more remote portions. The reverse of this will take place if we use a concave lens, or if we turn the refracting angles of the two prisms inwards.

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* See Report of the British Association at Swansea, 1848, Trans. of Sect., p. 48.

Hence it follows, and experiment confirms the inference, that we give solidity and relief to plane figures by a suitable application of color to parts that are placed at different distances from the eye.

These effects are greatly increased by using lenses of highly-dispersing flint glass, oil of cassia, and other fluids, and avoiding the use of compound colors in the objects placed in the stereoscope.

5. *Spots on the Sun*, (L'Institut, No. 984.)—M. Rodolph Wolf writes with reference to the recently discovered periodicity in the spots on the sun, that he is engaged upon an extended memoir on the subject, which will comprise all of importance that is on record respecting the spots since their discovery, and the results of his own observations. He has examined some 400 volumes in looking out the history of the subject. In the first chapter of his memoir, he will deduce from 16 different ascertained epochs of minimum and maximum, that the mean period for the spots should be fixed at $11{\cdot}111 \pm 0{\cdot}038$ years, so that 9 periods are just equal to a century. In the second chapter he will show that for each century, the years 0, 11·11, 22·22, 33·33, 44·44, 55·56, 66·67, 77·78, 88·89, correspond to the minima of solar spots. The interval between the minimum and maximum is variable, but averages five years. The third chapter will contain a historical notice of all the records of spots from Fabricius and Scheiner to Schwabe, with reference to the period ascertained. The fourth chapter points out certain analogies between the solar spots and the variable stars. The fifth will be devoted to showing that the period of 11·11 years corresponds more nearly with the variations in magnetic declination, than the period of $10\frac{1}{2}$ years established by Lamont. The magnetic variations follow the spots not only in their regular changes but also in their minor irregularities. The sixth chapter will contain a comparison between the solar spots and meteorological notes and registers at Zurich between the years 1000 and 1800. It follows, conformably to the views of Herschel, that the years when the spots are most numerous are in general more dry and more fertile than the others, the latter being more stormy as well as moist. The aurora borealis and earthquakes increase in a striking manner with the increase of the spots.

6. *Meteor observed at Toulouse by M. Petit, and at Bordeaux by M. Abria*, (L'Institut, No. 978, Sept. 29, 1852.)—The calculations made from the observations show that the meteor was 253 kilometers* from the earth when seen at Bordeaux, and from Bordeaux at the same time 268 kilometers; and when seen at Toulouse it was $149\frac{1}{2}$ k. from the earth. Apparent rapidity from M. Abria's valuation 214·4 k.; from M. Petit's, $62\frac{1}{2}$ k. Absolute rapidity in space, from M. Petit, 75 k. The diameter according to M. Petit's observations was 215 meters (=235 English yards); and he concludes that the meteor was a cosmical body moving in space.

7. *On a new Meteoric stone from Gütersloh.*—Last year M. Dove presented to the Prussian Academy at Berlin a meteoric stone which fell at Gütersloh on the 17th of April, according to the testimony of Dr. Stohlman. M. Rose has since received another large piece from the same locality and a fragment weighing over three ounces was sent

* A kilometer is 3280 English feet, or $\frac{62}{100}$ths of an English statute mile.

to the Academy by M. Stohlman. The cabinet of Meteorites at the Museum of Berlin contains meteorites from 97 localities, 33 of which are meteoric irons, and 64 meteoric stones. The whole known number of distinct meteoric irons according to Dr. Wm. S. Clarke now amounts to sixty.

OBITUARY.

Dr. Daniel Drake.—Dr. Drake died in Cincinnati, the city of his residence, on Saturday morning, November 7, being sixty-seven years old. He began the practice of medicine in Cincinnati, at the beginning of the present century, at which time that city was a village, with one brick house in solitary contrast to those of logs and boards about it.

Dr. Drake's name is the most eminent in the annals of Western medicine. His great work on the Diseases of the Valley of North America is the result of well-directed industry, and the most indefatigable research. The first volume only has yet been published. We trust that the second may be ready for the press, for otherwise his death will indeed be a double calamity to the public and to the profession. This work has been pronounced by competent medical critics to be one of high merit; and its foreign reputation is equal to that which it enjoys at home. It must ever remain an important portion of our permanent medical literature.

Apart from his labors in his profession, Dr. Drake, on various occasions, delivered lectures and orations on subjects of public interest, many of which have been published. They are marked by vigorous and original thinking, and by the practical value of their suggestions. They would afford materials for a valuable volume.

Dr. Drake was extremely fond of recalling the past. The scenes of his youth lived most vividly in his memory, and in his fervid descriptions, they glowed in all their original beauty and freshness. He was always ready to do justice to his cotemporaries; and in speaking of his own early and somewhat rough professional experience, he often brought in anecdotes creditable to those who were his competitors for the public favor. His memory was a store-house filled with an infinite variety of things both large and small, from the treatment of a hypochondriac patient fifty years ago, up to what had been written and said in relation to those great problems of humanity which have taxed the loftiest powers of the human mind in all ages.

In the decease of Doctor Drake, Cincinnati has lost one of her pioneer citizens, one of her greatest men, and the writer to whom she is most indebted for her prosperity. He dearly loved his city, which had grown up in the wilderness, immediately under his own eye. He had lived there when it was a little village, and he lived to see it a great city, the 'Queen of the West.' It is not strange then that he loved the city consecrated to his heart by affliction, by adversity and by prosperity—the city in which he had met with both success and suffering—where his affections had ripened, flourished and decayed—where the past was full of reminiscences of gladness as well as of gloom—where his home had been for half a century, a period marked by events of the highest importance.

As a lecturer on subjects connected with his profession, his reputation was unsurpassed by that of any of his coadjutors. As a medical lecturer, few have been engaged so long and so devotedly, while none have excited more general attention, or attracted a greater number of students anxious to listen to the wisdom which fell from his lips. He was, at the time of his decease, a member of the faculty of Ohio Medical College.

From what we know of his habits, we trust that he has left behind him ample materials for the construction of a biography. A well-written volume is due to his memory, and the incidents and the associations of his life will afford ample materials, full of interest and instruction. There are those still living who were his early associates and companions during the long period embraced by his professional life, and from them much may be gathered of deep interest in relation to our departed friend. He was always the friend of young men of talent and merit, and many are now on the stage of life who look back with feelings of profound gratitude to the generous sympathy and many kindnesses he showed them in their days of trial. He was not only a man of high talent, but he was also one of the most painstaking and laborious students that we have ever known. His success is mainly to be attributed to his unswerving diligence. He was never satisfied as long as he knew that he was ignorant of any of the phases of a subject. His example in this respect is valuable and ought to be followed by all those who aspire to fortune or to fame in their profession.

The facts in the above notice are somewhat abridged from an article published in a Cincinnati paper, and copied into the Louisville Weekly Journal. We believe them not to be exaggerated.

Dr. Drake was perhaps the first writer who called the attention of geologists to the drift and boulders in the vicinity of Cincinnati, and his little volume, in which the facts are contained, may still be read with advantage. B. S. SR.,

Prof. C. B. Adams.—The steamer *Petrel*, which arrived at New York from St. Thomas, W. I., on Saturday, brought the sad intelligence of the death at that place, of Prof. C. B. Adams, of Amherst College. Prof. Adams had become widely known in the scientific world, by his labors in the departments of Geology and Zoology; and in his unexpected demise, Science has to mourn the loss of a most indefatigable and accurate investigator. For some years he performed the duties of State Geologist of Vermont, and his reports in that capacity have been published. In conjunction with Mr. Gray, of Brooklyn, he had just completed and published a valuable elementary work upon geology. In several visits which he had made to Jamaica, he had thoroughly studied the marine, fluviatile and terrestrial mollusks of that island, and enriched its Fauna by the publication of several hundred new species. Within a few years past his attention had become particularly directed to *Zoological Geography*, a field in which he saw that a rich harvest of scientific truth was yet to be gathered. The last volume of the Annals of the Lyceum of Natural History of New York, contains the result of his sojourn for a few weeks at Panama, in the Winter of 1850–51, in the form of a treatise upon the Zoological Province of Panama, with a catalogue of its mollusks, and full notes upon their geographical distri-

bution. He had projected a similar but more elaborate work on the geographical distribution of the mollusks of the Caribbean Zoological Province, a work for which his previous visits to the West Indies had eminently qualified him. Impaired health rendering another visit to a warmer climate advisable, he had designed making this visit also subservient to the collecting of facts and material for his favorite object. But shortly after his arrival at St. Thomas, in December, he was attacked by the prevalent fever,—and when the friends around him hoped that he had passed the crisis of the disease, he suddenly sank from exhaustion, and died on the 19th of January.—*N. Y. Daily Times, Feb.* 1.

We have from time to time had occasion to notice the publications of Prof. Adams; and only in our last number we announced the appearance of his last great work, on the Mollusks of Panama, and the labors in which he was engaged in the neighboring seas. Some of the results of his investigations are embodied in the Paper in the preceding number (vol. xiv, p. 389) on the Geographical Distribution of Mollusca, by Mr. T. Bland.

Sears C. Walker.—This eminent astronomer and mathematician died on the 30th of January, 1853, at the residence of his brother, Judge Walker, on East Walnut Hills, near Cincinnati, Ohio.

Sears C. Walker was born at Wilmington, Mass., on the 28th of March, 1805; graduated at Harvard University in 1825; taught a private school in Philadelphia for several years; was for a considerable period actuary in the Pennsylvania Life Insurance Company; a short time attached to the National Observatory, but for several years preceding his death was one of the assistants of the U. S. Coast Survey.

As a child, his precociousness was the wonder of the village. At College, he was remarkable for his aptness in acquiring languages. Afterwards he became an enthusiastic devotee of science. The archives of the American Philosophical Society, Franklin Institute, Smithsonian Institution, and other learned societies here and in Europe, all attest a zeal for scientific research, which has at last resulted in his martyrdom. For the last three or four years, apart from his regular duties in the coast survey—of themselves sufficiently arduous—he has borrowed from needful rest so many hours, in order to discover the orbit and make the ephemeris of Neptune, and to determine the velocity of the transmission of the fluid along the telegraph wires, that about a year ago his brain gave way, and he was for several months in a lunatic asylum. In October last, he was thought to be so far recovered as to justify his removal from the asylum, and he came to Cincinnati on a visit to his brother. Here he gradually resumed his labors, both in computations for the coast survey and in the preparation of an ephemeris of Neptune for the American Nautical Almanac. In December, he had made all his preparations to depart for Washington, and resume his regular duties there as chief of a party in the survey, when an attack of bilious fever frustrated all his plans. From this fever he seemed to have recovered, but his frame again gave way, and this time without hope of a second rally.

In the circles of science, both here and abroad, his death will be deeply felt; for he had with them an extensive correspondence and a

growing reputation. But beyond these, and his own family circle, he was little known. In politics he never mingled. For the ordinary amusements and excitements of the world he had no taste. His one absorbing passion was a love of science, and that for its own sake. Seldom has there been a man so highly gifted, of more retiring modesty, or greater meekness and simplicity of character.—*Cin. Gaz., Feb.* 1.

[We subjoin the following sketch of Mr. Walker's scientific labors, given at a meeting of the officers and members of the U. S. Coast Survey, by Prof. A. D. Bache, Superintendent.—Eds.]

We have met to pay our tribute of respect and feeling to one of our most distinguished and valued associates, Sears C. Walker, Esq., whose failing health for more than a year past has kept us in anxiety and fear for the result which has now come. Mr. Walker was attacked by bilious fever some weeks since; and though his mind was clear, his physical strength was not adequate to resist the effects of the disease.

The services which Mr. Walker has rendered to the coast survey are known in a general way to most of those whom I address. He had made the largest collection of American observations of moon culminations and occultations ever made in the country, and prepared to discuss them thoroughly for longitudes, and to bring them to bear, as far as applicable, by the geodetic results of the coast survey, upon the longitude of a central point. The magnitude of this labor would have appalled an ordinary mind. He knew that by perseverance it could be accomplished. During this discussion he reached the conclusion that the longitudes from moon culminations could not be reconciled with those from occultations, and that the theory must be reëxamined for an explanation. His published reports show the successive steps of his investigation, which was not completed at the time of his decease. In the midst of it, the new, attractive, and important subject of determining differences of longitnde by the telegraph was committed to him, and he threw all his zeal and knowledge into the solution of this problem, and brought it to the successful condition in which it now is. He early saw the impossibility of reading a near result by merely repeating the transmission and reception of signals, beats of a clock or chronometer, and that the beats sent and received must be of time-keepers regulated to different times—as, for example, mean solar and sidereal, and seized all the consequences flowing from this principle. The telegraphing of transits of stars was original with him.

He soon became satisfied of the necessity for graphic registry of the time results, and invited the coöperation of Mr. Saxton, of Mr. Bond, of Prof. Mitchell, and of Dr. Locke in the solution. With him originated the application of this method to the registry of time observations for general astronomical purposes, now developed by so many ingenious modes, and known as the "American Method." His researches on galvanic wave-time, growing out of these experiments for difference of longitude, are by far the most valuable contributions yet made to this branch of science. In this subject alone Mr. Walker accomplished a most remarkable five years' work; but this was only a part of what his mind found there to do, and, aside from this and labors of daily and nightly routine in computing and observing, he accomplished a

work—investigation of the orbit and computation of an ephemeris of Neptune—which of itself would have given him an undying reputation. I cannot in this place describe how the training of a life was obtained which led to these brilliant results for our work, and for American science; nor can I trust myself now in an analysis of the mind and heart of this friend for many years. I have faintly pencilled his doings while closely connected with our work, shadowing merely his claims to our admiration, respect, and gratitude.—*Republic, Feb.* 8.

William MacGillivray.—This distinguished naturalist had just completed the fourth and fifth volumes of his History of British Birds, before his death in September last. He was already on the brink of the grave when his work was completed; and his concluding message to his readers is his farewell to the world. He closes with the following noble sentiments. "I have been honest and sincere in my endeavors to promote the truth. With death, apparently not distant, before my eyes, I am pleased to think that I have not countenanced error, through fear or favor. Neither have I in any case modified my sentiments so as to endeavor thereby to conceal or palliate my faults. Though I might have accomplished more, I am thankful for having been permitted to add very considerably to the knowledge previously obtained of a very pleasant subject. If I have not very frequently indulged in reflections on the power, wisdom, and goodness of God, as suggested by even my imperfect understanding of his wonderful works, it is not because I have not ever been sensible of the relation between the Creator and his creatures, nor because my chief enjoyment when wandering among the hills and valleys, exploring the rugged shores of the ocean, or searching the cultivated fields, has not been in a sense of His presence. 'To Him who alone doeth great wonders,' be all glory and praise. Reader, farewell."*

The first three volumes of his work on British birds were published in 1837. Besides this, his great work, he published various memoirs on birds in the Wernerian Transactions and elsewhere; the "Conchologist's Text-Book," which passed through six editions; a "History of the Molluscous Animals of the counties of Aberdeen, Kincardine, and Banff;" a "Manual of Geology," a volume on "British Quadrupeds," forming the seventh of Jardine's Naturalists Library, besides various other works and memoirs.

VII. Bibliography.

1. *Report on the Geology of the Lake Superior Land District;* by J. W. Foster and J. D. Whitney, U. S. Geologists. Part II. The Iron Region together with the General Geology. 406 pp., 8vo. Senate Document, Special Session, March, 1851; Executive No. 4.—The first part of Messrs. Foster and Whitney's Geological Report was noticed at some length in vol. xii, (p. 222) of this Journal. This second part enters more fully into geological details and principles, and embraces observations of the highest value to the science. Many points in the geology of the United States are ably discussed, and established as a

* Athenæum, 1852, p. 998.

part of the now known history of ancient epochs in this hemisphere. Among these, is the age of the extensive red sandstone formation of the Lake Superior region, which more from its intersection by trap dykes rather than from any other reason, was formerly referred to the same age with the Connecticut river red sandstone. It appears to be settled that these rocks, as Messrs. Foster and Whitney announced in the first part of their Report, are as old as the lowest Silurian. The occurrence of Lingula and Trilobites in this group, must be considered, the authors observe, as conclusively settling its age. Mr. Logan of Canada, from surveys there made, announces that the evidence is clear and indisputably conclusive.

The volume presents in the third, fourth and fifth chapters, a full exhibition of the characters of the azoic system which they recognize as existing in this and other countries below the lowest Silurian or Cambrian. The Trap Rocks, Lower Silurian system, Upper Silurian and Devonian systems with their Fossils, are treated with fullness in chapters 6 to 13; part of which are by the learned palæontologist, Mr. James Hall. Chapters 15 and 16 on Superficial Deposits, are by Mr. E. Desor. Chapter 17 takes up the subject of the Elevation of Mountain Chains, in which the views of Elie de Beaumont are accepted. Chapter 18, by James Hall, discusses the Parallelism of the Palæozoic Deposits of Europe and America. The following pages are upon the fluctuations of the surfaces of the lakes, by C. Whittlesey; magnetic variations and comparison of Terrestrial and Astronomical Measurements, by C. Whittlesey; and the Botany of the Region, by W. D. Whitney. The volume is abundantly illustrated, and twelve plates are devoted to fossils. There are also three large folded maps, forming a separate thin octavo volume.

2. *Report of a Geological Survey of Wisconsin, Iowa and Minnesota, and incidentally of a portion of Nebraska Territory, made under Instructions from the United States Treasury Department;* by DAVID DALE OWEN, U. S. Geologist. 638 pp., 4to, with numerous wood-cuts, and a 4to volume of plates and maps. Philadelphia, 1852.—The Report of Dr. Owen is elegant in its typography and illustrations and able in its science. The author, among the first of American geologists, has contributed in his Report very largely to our knowledge of the rocks and fossils of the West, and to the general progress of geological science. The volume gives elaborate descriptions of the geological formations of the Upper Mississippi, taking up the several rocks in order, describing their features, materials, fossils, range, extent, and economical bearing.

Next follow Dr. J. G. Norwood's Report on the Geology of Middle and Western Minnesota; Col. Whittlesey's Report on Wisconsin south of Lake Superior; Dr. B. F. Shumard's Report on Geological Sections of the St. Peter's, Mississippi, Wisconsin, Barraloo, Snake and Kettle River; Dr. Joseph Leidy's Memoir on the Fossil Mammalia and Reptilia collected during the survey, in which are descriptions of several new genera as well as species. An Appendix on the fossils, and additional chemical examinations by the author, with a catalogue of plants by C. C. Parry, and birds by H. Pratten, close this large and most important volume. The quarto volume of plates, contains fifteen plates of

fossils, of unusual beauty, (seven of which are devoted to the remarkable mammalia from the Eocene tertiary of Nebraska,) besides various views, sections and maps. We might interest our readers with extended citations from its pages, but can add in this place only the following extracts relating to

The general features and ancient Mammalia of the Mauvaises Terres of Nebraska.

"After leaving the locality on Sage creek, [a southern branch of the Cheyenne,] affording the above-mentioned fossils, [fossil ammonites, &c. of the Eocene tertiary,] crossing that stream, and proceeding in the direction of White river, about twelve or fifteen miles, the formation of the Mauvaises Terres proper bursts into view, disclosing, as here depicted, one of the most extraordinary and picturesque sights that can be found in the whole Missouri country.

From the high prairies, that rise in the background, by a series of terraces or benches, toward the spurs of the Rocky Mountains, the traveller looks down into an extensive valley, that may be said to constitute a world of its own, and which appears to have been formed, partly by an extensive vertical fault, partly by the long-continued influence of the scooping action of denudation.

The width of this valley may be about thirty miles, and its whole length about ninety, as it stretches away westwardly, towards the base of the gloomy and dark range of mountains known as the Black Hills. Its most depressed portion, three hundred feet below the general level of the surrounding country, is clothed with scanty grasses, and covered by a soil similar to that of the higher ground.

To the surrounding country, however, the Mauvaises Terres present the most striking contrast. From the uniform, monotonous, open prairie, the traveller suddenly descends one or two hundred feet, into a valley that looks as if it had sunk away from the surrounding world; leaving standing, all over it, thousands of abrupt, irregular, prismatic, and columnar masses, frequently capped with irregular pyramids, and stretching up to a height of from one to two hundred feet, or more.

So thickly are these natural towers studded over the surface of this extraordinary region, that the traveller threads his way through deep, confined, labyrinthine passages, not unlike the narrow, irregular streets and lanes of some quaint old town of the European continent. Viewed in the distance, indeed, these rocky piles, in their endless succession, assume the appearance of massive artificial structures, decked out with all the accessories of buttress and turret, arched doorway and clustered shaft, pinnacle, and finial, and tapering spire. One might almost imagine oneself approaching some magnificent city of the dead, where the labor and the genius of forgotten nations had left behind them a multitude of monuments of art and skill.

On descending from the heights, however, and proceeding to thread this vast labyrinth, and inspect, in detail, its deep, intricate recesses, the realities of the scene soon dissipate the delusions of the distance. The castellated forms which fancy had conjured up have vanished; and around, on every side, is bleak and barren desolation.

Then, too, if the exploration be made in midsummer, the scorching rays of the sun, pouring down in the hundred defiles that conduct the

wayfarer through this pathless waste, are reflected back from the white or ash-colored walls that rise around, unmitigated by a breath of air, or the shelter of a solitary shrub.

The drooping spirits of the scorched explorer are not permitted, however, to flag. The fossil treasures of the way, well repay its sultriness and fatigue. At every step, objects of the highest interest present themselves. Embedded in the debris, lie strewn, in the greatest profusion, organic relics of extinct animals. All speak of a vast fresh-water deposit of the early Tertiary Period, and disclose the former existence of most remarkable races, that roamed about in bygone ages high up in the Valley of the Missouri, towards the sources of its western tributaries; where now pastures the big-horned *Ovis montana*, the shaggy buffalo or American bison, and the elegant and slenderly constructed antelope.

Every specimen as yet brought from the Bad Lands, proves to be of species that became exterminated before the mammoth and mastodon lived, and which differ in their specific character, not alone from all living animals, but also from all fossils obtained even from cotemporaneous geological formations elsewhere.

Along with a single existing genus, the Rhinoceros, many new genera never before known to science have been discovered, and some, to us at this day, anomalous families, which combine in their anatomy structures now found only in different orders. They form, indeed, connecting links between the pachyderms, plantigrades, and digitigrades. For example, in one of the specimens from this strange locality, described by Dr. Leidy under the name of *Archæotherium*, we find united characters belonging now to the above three orders; for the molar teeth are constructed after the model of those of the hog, peccary, and babyroussa; the canines as in the bear; while the upper part of the skull, the cheek-bones, and the temporal fossa assume the form and dimensions which belong to the cat tribe. Another, the *Oreodon* of Leidy, has grinding teeth like the elk and deer, with canines resembling the omnivorous thick-skinned animals; being, in fact, a race which lived both on flesh and vegetables, and yet chewed the cud like our cloven-footed grazers.

Associated with these extinct races, we behold also, in the Mauvaises Terres, abundant remains of fossil pachydermata, of gigantic dimensions, and allied in their anatomy to that singular family of proboscidean animals, of which the tapir may be taken as a living type. These form a connecting link between the tapir and the rhinoceros; while, in the structure of their grinders, they are intermediate between the daman and rhinoceros; by their canines and incisors, they connect the tapir with the horse, on the one hand, and with the peccary and hog on the other. They belong to the same genus of which the labors of the great Cuvier first disclosed the history, under the name of *Palæotherium*, in publishing his description of the fossil bones exhumed from the gypsum quarries of Montmartre, near Paris, but are distinct in species; and one, at least, of this genus, discovered in the Bad Lands (*Palæotherium Proutii*), must have attained a much larger size than any which the Paris basin afforded. In a green, argillo-calcareous, indurated stratum, situated within ten feet of the base of the section, a jaw of

this species was found, measuring, as it lay in its matrix, five feet along the range of the teeth, but in such a friable condition, that only a portion of it could be dislodged; and this, notwithstanding all the precautions used in packing and transportation, fell to pieces before reaching Indiana." * * * *

The author continues with remarks on other Fossil Mammalia from this singular region. Descriptions of the above and other fossils, including four species of Fossil Turtle, are given in the chapter by Dr. Leidy.

With regard to the Lake Superior Sandstone, Mr. Owen arrives at the same conclusion essentially with Messrs. Foster and Whitney, that it is as old at least as the lowest Silurian. Dr. Owen even suggests that it probably underlies the Lingula and Orbicula beds of the Upper Mississippi valley.

3. *A History of Infusorial Animalcules, living and fossil, illustrated by several hundred magnified representations;* by ANDREW PRITCHARD, M.R.I., &c. A new edition, enlarged. London: 1852.—In preparing the new edition of this useful work, Mr. Pritchard has been aided by J. T. Arlidge, and the result of their united labors has been the production of a volume containing a large amount of new and interesting matter in addition to the contents of the preceding edition. Without increasing the cost of the work, the number of engravings has been doubled, and many additions have been made to the text. Among these are compilations from Ehrenberg's numerous papers read before the Berlin Academy, including the description of many new genera and species. The admirable work of Ralfs on the Desmidieæ has been adopted as the basis of the chapter on these forms, while other valuable matter is drawn from the Annals and Magazine of Natural History, and from the writings of Kützing, Dujardin, Siebold, Stein, &c. In fact, great industry appears to have been exerted in collecting every thing novel relating to the Infusoria. We must however, express our regret that the editors have not devoted more time to the arrangement and connection of the heterogeneous materials thus assembled. It is true that it well represents the present state of this department of science, in which all is in confusion. But there are parts of the subject which are no longer doubtful, and we regret that we are presented with many erroneous generic and specific characters taken from the now obsolete descriptions of Ehrenberg, Kützing and others. We allude more particularly to the constant allusion to "*apertures*" in the shells of the Diatomaceæ, and to the application of the term "*smooth*" to the surface of various siliceous shells which may readily be shown to be lined objects by a good objective of even one inch focal distance. We observe that Schleiden's denial of the existence of apertures in the Navicula, &c. is given, and also his assertion that the so-called apertures are merely depressions, while Dujardin considers them as elevations of the surface of the shell; but the editors appear to have overlooked the decision of these questions afforded by the action of hydrofluoric acid, (see this Journal, xi, 349,) by means of which it has been put beyond all doubt that the apertures have no existence, and that what have borne this name are neither elevations nor depressions merely, but in reality the thickest portion of the shells. As many of

Ehrenberg's generic characters, as well as Kützing's classification of the Diatomaceæ into Astomaticæ and Stomaticæ are founded on errors with regard to these supposed apertures, their descriptions as quoted in this volume, require important corrections. With regard to many a species described as smooth, and indeed not only as "levis," but "levissima," by Ehrenberg and by Kützing, we do not hesitate to assert that not one of them is smooth. In fact, a Diatomaceous shell on which no markings can be made out by Spencer's best lenses is yet to be sought for. We would not be understood to cast any censure upon the great German writers above mentioned, for their erroneous observations were made many years since, with instruments so poor that it is only to be wondered at that they accomplished so much with them. Three years after the publication of Ehrenberg's great work in 1838, it was thought a matter worth recording in the London Microscopic Journal (see vol. ii, p. 224,) that the Navicula Hippocampus, Ehr., mounted dry, could be made to show transverse lines by careful management of the light, while at present it is considered as one of the coarsest of the test objects furnished by the Naviculæ.

In connection with this subject, we quote the following remarks in which the difficulty of resolving the markings on the Diatomaceous test objects is greatly overrated. The authors state that "those who make the structure of these shells a special study, require from forty to fifty minutes manipulation with a first rate instrument, and all the modern appliances for obtaining intense oblique light, before they can shew certain striæ or dots on a well known specimen." Now we know by numerous trials made with Spencer's objectives upon the most difficult test object now known, viz. the Grammatophora from Providence, R. I., that after the shell to be examined is once brought into the field of view, two minutes is a very large allowance of time for the exhibition of its markings by sunlight, and this too, without any of the ingenious appliances for oblique illumination, on which the London artists have lately devoted so much labor.

We regret to see numerous typographical errors in this edition, and among others one on page 102 which deprives Spencer of the credit of 30° of aperture beyond what is there stated. Instead of his objective having an angle of 147° as there stated, it should be 174°*.

Although we have thus pointed out some faults of this edition, we yet can sincerely say that there is no work extant in which so much valuable information concerning the Infusoria can be found, and every microscopist should add it to his library.

4. *On the Origin of the Forms and Present Condition of some of the Clusters of Stars and several of the Nebulæ;* by STEPHEN ALEXANDER, Prof. Math. and Astron. in the College of New Jersey, (from the Astronomical Journal, Nos. 36 to 44, 1852.)—The plates illustrating this remarkable paper represent various nebulæ as developed by the recent telescopes of Lord Rosse, Herschel and other observers. Some are simple elliptical clusters, with a brighter center; others consist of two or three rings with an irregular fringe to the exterior; some are literally broken rings; others are like dumb-bells; others like a

* See this Journal, 2nd Ser., vol. xiii, p. 31.

comma in form, having a circular head, produced on one side into a long spirally curving extremity. And others seem like tornadoes in the heavens, whose currents rushing spirally about a center carry worlds in their course in place of clouds of dust. Col. Sabine states in his recent address before the British Association, that no known laws of force have hitherto been found sufficient to explain the strange mode of aggregation of worlds exhibited by nebulæ. Prof. Alexander has undertaken to review and compare these various forms, and endeavors to trace their correspondence with the nebular theory, extending and modifying it so as to embrace the universe. He concludes that the clusters of stars and nebulæ are "*the partially scattered fragments of enormous masses, once rotating in a state of dynamical equilibrium; and that the separation of these fragments may still be in progress.*" The author, after some observations on the motions and conditions of a homogeneous fluid mass and the rates essential to its preserving a spheroidal form, takes up the classes of nebulæ in order, and points out the processes of development through which they may be supposed to have passed. He considers first those whose original form was a highly oblate spheroid, under which fall the spirals and elliptic nebulæ; second, those in which the original was a spheroid of small ellipticity; third, those having for the primitive or early derivative form a ring, besides other varieties. The milky way is compared to one of the spirals. We should do injustice to the author by any abstract we might make of his paper, especially without his elegant plates, and we, therefore, refer our readers to the paper itself in the Astronomical Journal.

5. *Chemical Field Lectures for Agriculturists;* by Dr. Julius Adolphus Stöckhardt, Prof. in the Royal Acad. of Agric., at Tharand. Translated from the German. Edited with notes by James E. Teschemacher. 242 pp., 12mo. Cambridge, 1853: J. Bartlett.—Prof. Stöckhardt's work consists of Lectures or Chapters on practical subjects connected with Agriculture—viz.: the Nourishment of Plants—Increasing the Growth of Plants by Manuring—Excrements and Urine as manures—Drainings—Stall-manure and Straw—Importance and value of Artificial Manures—Guano—Bones—Oil Cake—Malt grains or Refuse from Breweries. The author has presented these subjects in a style as free as possible from scientific technicalities, and made a work highly useful to the farmer and horticulturist, rendering science in fact the companion and servant of man in his labors with the soil. Mr. Teschemacher, who has much practical and scientific acquaintance with guano and other fertilisers, has added much to the value of the work by various notes through the volume.

6. *Principles of Human Physiology, with their chief applications to Psychology, Pathology, Therapeutics, Hygiene and Forensic Medicine;* by Wm. B. Carpenter, M.D., F.R.S., F.G.S., Examiner in Physiology and Comparative Anatomy in the University of London, &c. Fifth American from the fourth and enlarged London edition, with 314 illustrations. Edited with additions by Francis Gurney Smith, M.D., Professor of Medicine in the Medical Department of Pennsylvania College, &c. 1091 pp., 8vo, 1853. Philadelphia.—Carpenter's Human Physiology is too well known and too highly appreciated to need commendation. This new edition by Lea and Blan-

chard has received many and large additions, increasing very much its value. It makes the previous editions appear altogether antiquated. The author in his Preface, observes "that on commencing the preparation of the new edition (fourth) he found that nothing short of an entire remodelling of the preceding edition would in any way satisfy his notions of what such a treatise should be." He was led therefore to the production of literally a new treatise. The changes have made a more thorough, systematic and practical work. A chapter, on the chemical components of the human body and the changes which they undergo within it, is entirely new; and another on the structural elements of the human body and the vital actions which they exhibit, is mostly so. The changes also in the chapter on the functions of the nervous system are very extensive and important.

7. *Industrial Drawing, comprising the Description and Uses of Drawing Instruments, the Construction of Plane Figures, the Projections and Sections of Geometrical Solids; Architectural Elements, Mechanism and Topographical Drawing; with remarks on the Method of teaching the subject. For the use of Academies and Common Schools;* by D. H. MAHAN, LL.D., Professor of Civil Engineering, &c., &c., in the U. S. Military Academy. 156 pp., 8vo. New York, 1852: J. Wiley.—The ability and thoroughness of the works of Prof. Mahan of West Point are well known. This volume is one much needed and is well adapted for its end. It enters into the principles and practice of drawing in all its various departments, even to forms of complex character, and illustrates the subject by various plates.

8. *American Polytechnic Journal, devoted to Science, Mechanic Arts and Agriculture;* conducted by Prof. C. G. PAGE, J. J. GREENOUGH, M.E., and CHAS. C. FLEISCHMANN, C.E. Vol. I, No. 1, Jan., 1853. 80 pp., large 8vo. A monthly at $3,00 per annum.—The promised appearance of this Journal was announced in our last. The number for January opens with some important papers on electro-mechanics by Prof. Page. Practical chemistry, especially relating to metals and alloys, occupy eight or ten pages. Several subjects connected with patents are next treated of, and among them "Patents for Improvements in making Sugar." Articles on agriculture, vine culture, merino sheep, and various miscellaneous articles of practical value or general interest close the number. This Journal will be found highly useful to all engaged in the mechanic arts, to any who are interested in patents or inventions, to the miner and worker in metals, to the agriculturist, and not less, to the man of science or general reader. Besides original papers, it presents records of recent discoveries both in this country and Europe, and also full lists of patents issued in the United States, with explanations or details of those of special importance.

9. *Sixth Annual Report of the Board of Regents of the Smithsonian Institution, to the Senate and House of Representatives, showing the Operations, Expenditures and Condition of the Institution during the year* 1851, *and the Proceedings of the Board of Regents up to date.* 104 pp., 8vo. Washington, 1852.—This institution is pursuing a noble course in its publication of original works and memoirs that constitute a real advance in knowledge. It is thus becoming a rich source of new truths from which all may draw who wish to promote the general enlightenment and progress of the country. We not un-

frequently hear complaints that the funds are not mainly used for the *diffusion* of knowledge. But the simple fact, as the Secretary states, that a single Patent Office Report often costs three time as much as the whole income of the Smithsonian fund, shows how utterly impossible it is to make this its prominent object. The Patent Office volume, notwithstanding the expenditure, is seen by few, and a complete series of the Reports is to be found in but a *very* small number of the libraries in the land.

10. *On the Extinct Species of American Ox*, from the Smithsonian Contrib., vol. v; *Description of an Extinct Species of American Lion, Felis atrox, and a Memoir on the Extinct Dicotylinæ of America*, from the Transactions of the American Phil. Soc., vol. x; by JOSEPH LEIDY, M.D. 4to, with 9 lithographic plates.—Dr. Leidy has made large contributions to our knowledge of the ancient Mammalia of this country. Twenty species of large quadrupeds have been named by him from the Nebraska Tertiary alone, ten of which, including two of rhinoceros, are described in Dr. Owen's Geological Report, noticed on a preceding page. The memoirs whose titles are above cited, contain descriptions of other species. Of American Fossil Ox, he enumerates 4 species, *Bison latifrons*, L., (Bos latifrons, *Harlan*,) Bison antiquus, L., Bootherium (L.) cavifrons, L., (Bos Pallasii, *De Kay*,) B. bombifrons, L., (Bos bombifrons, *Harlan*.) The second paper is the first announcement as yet made of an American Lion, and the species which he calls the *Felis atrox* was much larger than the recent tiger or lion, or the extinct *Felis spelæa* of Europe. It is from Natchez, Miss. The third paper presents a review of the species with many anatomical details of the Dicotylinæ which take the place in America of species of Sus. The lithographic plates illustrating these papers are excellent, and exhibit minute care and precision in the drawings.

11. *Proceedings of the Academy of Natural Sciences of Philadelphia.*—The Proceedings of the Academy are issued every two months and make every two years, a volume of 350 to 400 pages. They contain a large amount of matter on Zoology and other sciences, including numerous descriptions of new species, and announcements of new facts, or principles, by some of the ablest scientific investigators in the United States. They are sent to subscribers for the small charge of $1 per annum, in advance, this amount barely covering the cost of publication. Five volumes have been issued and the *sixth* is now in progress. Price for the first five volumes 8 dollars. Address Dr. Wm. S. Zantzinger, or W. S. Vaux, Esq., Philadelphia.

C. M. WETHERILL, Ph. D.: Chemical Examination of Two Minerals from the neighborhood of Reading, Pa., and on the occurrence of Gold in Pennsylvania; and on a new variety of Asphalt, Melan-asphalt. From the Trans. Amer. Phil. Soc., 8 and 8 pp. 4to.—These and other papers of Dr. Wetherill we shall cite from in our next.

N. S. MANROSS: Experiments on the Artificial production of Crystallized Minerals; an Inaugural Dissertation on Promotion to the rank of Doctor of Philosophy at the Georgia Augusta University. 32 pp., 8vo. *Göttingen*, 1852.—This important paper is the result of researches in the Laboratory of Prof. Wöhler. Other papers on hand have prevented our inserting it in the present number of our Journal.

THE COUNTRY GENTLEMAN: A weekly Journal for the Farm, the Garden and the Fireside, of 16 pp. 4to. Published at Albany, New York, by Luther Tucker, and devoted to The Farm, The Garden and Orchard, Rural Architecture, The Fireside, &c. Price $2 a year if paid in advance—$2 50 if not paid in advance.

C. GIRARD: Bibliographia Americana Historico-Naturalis, for 1851, 60 pp., 8vo. December, 1852. Published by the Smithsonian Institution.

C. MACFARLANE: Japan; an account, Geographical and Historical, with numerous illustrations. 365 pp., 12mo. *New York*, 1852. G. P. Putnam & Co.

H. T. TUCKERMAN: Sicily, a pilgrimage. 187 pp., 12mo. *New York*, 1852. G. P. Putnam.

PROCEEDINGS BOSTON SOC. NAT. HISTORY.—NOVEMBER, 1852.—p. 226. On some peculiarities of the economy of reproduction in certain insects; *W. I. Burnett.*—p. 228. On New Ascidia from the U. S. coast; *M. Stimpson.*—Observations on some Moa bones; *Dr. Kneeland.*—p. 240. Note on Alligators teeth; *J. Wyman.*—DECEMBER.—On a nest of the Bream (Pomotus vulgaris) in gravel at the bottom of a pond; *C. T. Jackson.*—p. 243. Two new genera and three new species of Holothuria; *W. O. Ayres.*—p. 247. On the crystalline lens and its formation; *W. I. Burnett.*—p. 248. On two new Ophiuridæ, from the coast of South Carolina; *W. O. Ayres*—p. 252. On the crystalline lens.

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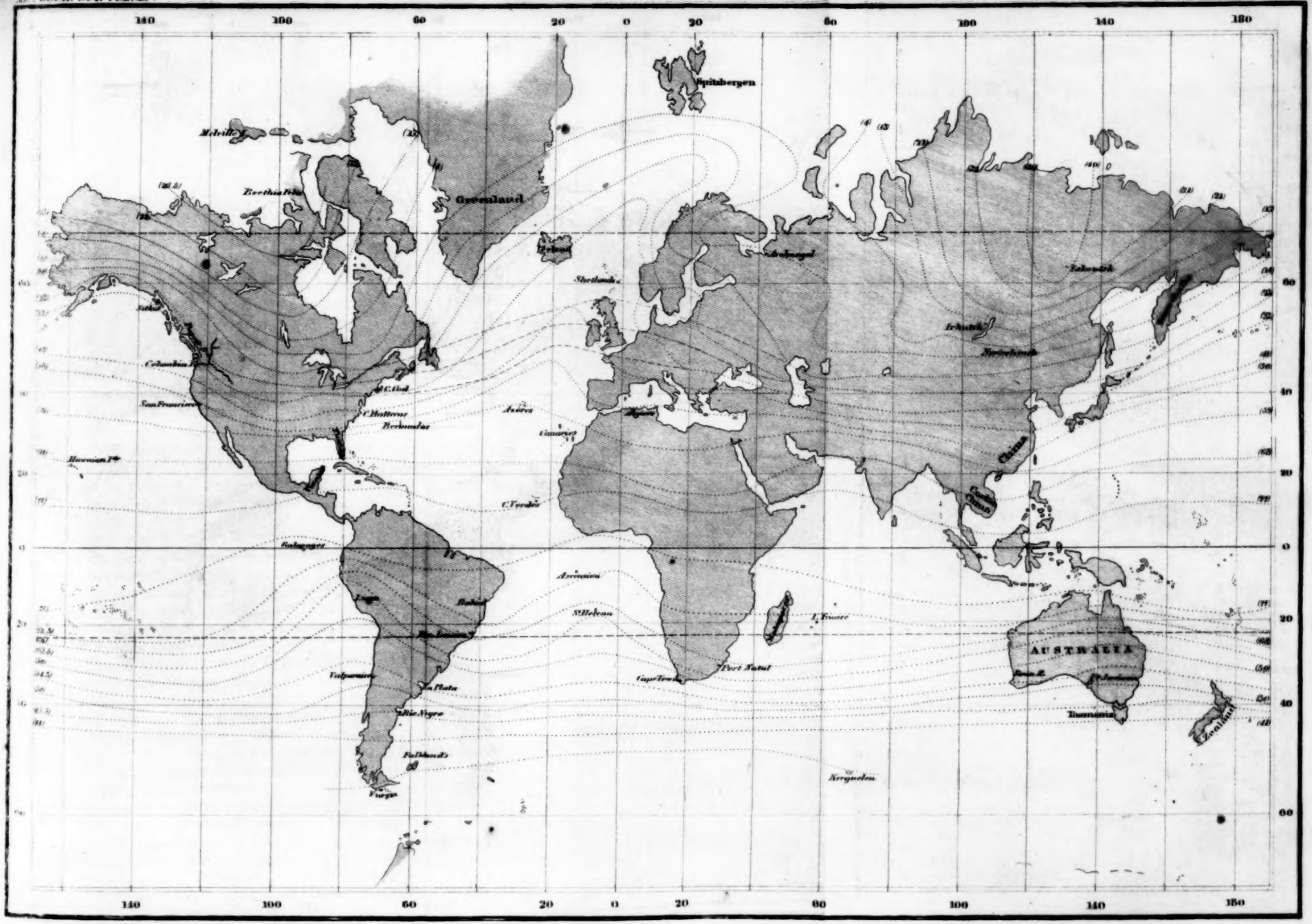
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